Design and Development of DASH: Design Assessment Framework and Tool for Sustainable Housing

A Thesis Submitted in Partial Fulfilment of the Requirements for the Degree of
DOCTOR OF PHILOSOPHY
by

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CERTIFICATE

In this immense journey, This is to certify that the research work presented in this thesis entitled "Design and Development of DASH: Design Assessment Framework and Tool for Sustainable Housing" has been carried out under my supervision and submitted by Ms. Kratika Piparsania. This work submitted for the degree of Doctor of Philosophy is original and has not been submitted elsewhere for the award of any other degree or diploma.

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DECLARATION

It is to certify that the work contained in this thesis entitled "Design and Development of DASH: Design Assessment Framework and Tool for Sustainable Housing" has been carried out by me, a student in the Department of Design, Indian Institute of Technology Guwahati under the guidance of Dr. Pratul Chandra Kalita for the award of Doctor of Philosophy and that this work has not been previously included in a thesis or dissertation submitted to this or any other institution for a degree, diploma or other qualifications. I have attempted to identify all the risks related to this research that may arise in conducting this research, obtained the relevant ethical and/or safety approval (where applicable), and acknowledged my obligations and the rights of the participants.

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"People do not decide to become extraordinary.

They decide to accomplish extraordinary things."

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ABSTRACT

The idea of sustainability is based on three pillars: environmental, economic, and social, per the Brundtland report. Housing is a type of architecture with which any occupant can connect. It is a place that supports an occupant's physical, emotional, cultural, and social needs, which support their consciousness. The methodology includes an extensive literature review, data collection, and analysis to understand, achieve, and balance sustainability. The study identified an evident gap in current green building rating systems regarding the inclusion of social and cultural indicators. There is an inclination for quantitative approaches, such as energy, the environment, and resources. The study found that it is viable to identify, recognize, and determine social and cultural indicators that are both tangible and intangible.

There is a need to cater to more sustainable housing that is socially and culturally appropriate for the transition to a low-carbon future. In most research regarding the sustainable built environment, participation and feedback are limited to industry experts and professionals, and residents are excluded. This study presents residents' views regarding the incorporation of socio-cultural indicators and the understanding of sustainability. This study focuses on socio-cultural sustainability: incorporating culture as the fourth pillar of sustainability or as an extension of social sustainability. This study attempted to fill this gap by collecting data from Indian residents, thus validating social and cultural indicators according to occupants' needs. Through a secondary data review and survey research, this study intends to find relevant socio-cultural indicators that are occupation-defined. The context of this study is specific to India and its residents, with a limited set of people involved due to restrictions resulting from COVID-19. This study aims to determine a way to more effectively integrate the physical and intangible aspects of housing for socio-culturally focused and sustainable development by establishing a theoretical framework.

The developed theoretical framework is further translated into a practical toolkit. The assessment tool is designed and developed in Microsoft Excel. Each section has design guidelines based on sustainable design practices and best practices followed by national standards and codes. The categories of the tool are identified in the framework and are sectioned into various categories and sub-categories. The template is made in a spreadsheet format, and the tool is designed and

developed using Microsoft excel. Each sub-category is detailed with specific design guidelines. The guidelines are based on sustainable design practices and best practices followed by national standards and codes. The scoring for the entire sheet and every section is on a scale ranging from "Poor" to "Best Practice" with score values (-1, 0,3,5), which are color-coded. All criteria within each category have been assigned equal weightage (i.e., 3 for good practice) except for innovation which is 1. The score of each section is calculated and reported after every sub-category's data. The final score calculations for the overall category are displayed at the bottom of the worksheet. The last tab, "Result," provides a concise summary of all the data, divided by category and multiple graphical charts. The toolkit covers seven categories of effect, identified as they have the most significant potential to reduce a building's environmental impact and remove the most frequently met problems and barriers in a balanced, sustainable design. The tool is later validated by industry experts who have worked in the development of similar assessment tools. The tool is checked with heuristics principles for user interface testing with the help of participant observation. The tool version V1 is revised based on the feedback received, and further V2 is developed and validated.

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TABLE OF CONTENTS

List of Figures

List Of Tables

Chapter 1

INTRODUCTION:

The Sustainability Context and Research Background

1. INTRODUCTION: The Sustainability Context and Research Background

1.1. Introduction To Sustainable Development

Sustainable development promotes a diverse, resilient, and healthy future for individuals and the environment. Measuring the components that indicate the growth of such sustainability is necessary for any field of study or practice (Cutaia, 2016). Adopting sustainable solutions in the built environment faces a significant measurement issue, primarily because no preset list of indicators is commonly agreed upon (Böhringer & Jochem, 2007; Verma & Raghubanshi, 2018). To promote sustainable development, the United Nations suggested the "three pillars" structure (Tweed & Sutherland, 2007).

The Brundtland Commission, formerly known as the World Commission on Environment and Development (WCED), initially introduced the idea of sustainable development in 1987 as part of the report titled "Our Common Future" (Brundtland, 1987). Sustainable development is defined in this report as "development that satisfies current demands without compromising the ability of future generations to satisfy their own needs" (Brundtland, 1987). Regarding social sustainability, culture occasionally presents a component or dimension. The World Commission on Culture and Development Report "Our Creative Diversity" was produced because of discussions about the interplay between culture and development during the UNESCO Decade of Culture and Development years 1988–1997 (Pérez de Cuéllar et al., 1996). While the social indicator is a well-established component of the sustainable development concept, there is ongoing discussion regarding the need to include a fourth component, the cultural dimension (Chan et al., 2012; Daniel et al., 2012; UNESCO, 2010). According to Hawkes, the researchers contend that, while presenting the case for culture as the fourth pillar of sustainability, cultural vitality is just as crucial to sustainable development as social equality and compares cultural diversity to biodiversity (Hawkes, 2001).

1.2. Three Pillars Of Sustainability

The Brundtland study in 1987 was the first to refer to the environmental, social, and economic aspects as the three pillars of sustainability (Brundtland, 1987). These three pillars serve as the foundation for sustainable development because none can exist in isolation for one another to

succeed: environmental preservation, social inclusion, and economic viability, as seen in Figure 1.1. Although cultural and political/ institutional dimensions are also present, Agenda 21 (1992) and the Brundtland Report (1987) both potentially implicitly articulate different social, economic, and environmental aspects of "sustainable development" (Brundtland, 1987; United Nations, 1992b). The phrase "economic, social, and environmental elements" of sustainable development is mentioned in Agenda 21's 8.4.1, but no conceptual foundation or framework is provided (United Nations, 1992b). When the General Assembly United Nations implemented the finalized SDGs in 2015, the objectives of the goals were described as “integrated and indivisible and balance the three dimensions of sustainable development: the economic, social and environmental,” However, the framework for the 17 goals does not explicitly include these elements (United Nations, 2015).

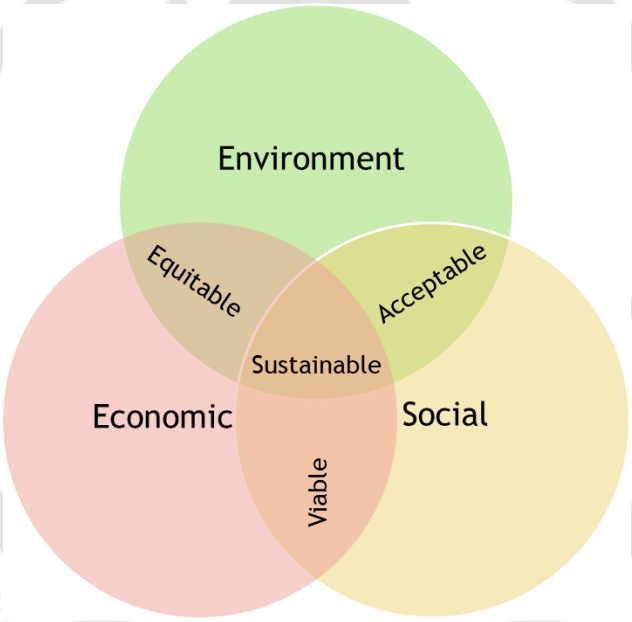

Figure 1.1 Three Pillars of Sustainability

Economic sustainability fosters long economic growth without compromising the community's social, environmental, or cultural aspects. A strategy that satisfies current demand levels without endangering future needs is necessary for financial sustainability (Lobo et al., 2015). Since they believed that the supply of natural materials was limitless earlier, economists overemphasized the market's capacity to allocate resources effectively (Du Q. & Kang J. T., 2016). They also believed that technological advancement would go hand in hand with economic expansion to replenish

natural resources used in production (Cooper & Vargas, 2004). As has been realized, these resources are finite and not all renewable or sustainable. The increasing economic system has overstretched the natural resource base, requiring a reassessment of conventional economic theories (Basiago, 1998; Du Q. & Kang J. T., 2016). Retchless and Brewer argue that because economic growth is the main priority, important cost variables are ignored, like the effects of pollution and resource depletion. At the same time, increasing consumer demand for products and services tries to push markets and mitigate environmental harm (Retchless & Brewer, 2016). Therefore, decisions must be made in the most moral and financially responsible way possible while considering other sustainable development issues to achieve economic sustainability (Zhai & Chang, 2019).

Social sustainability includes the ideas of equity, empowerment, accessibility, participation, identity and culture, and organizational stability (Daly, 1992). It implies that people are essential since growth is all about people (Benaim et al., 2008). Social sustainability, in essence, refers to a social framework that lessens poverty, according to Littig and Grießler (Littig & Grießler, 2005). Social sustainability holds that eliminating poverty shouldn't lead to unwarranted environmental deterioration or unstable economic situations (Kumar et al., 2014). Sustainable development at the social level necessitates promoting the growth of people, communities, and cultures while helping to promote gender inclusiveness in education, medical services, and other fields, as well as global stability and peace. It should focus on reducing poverty while utilizing the current societal existing financial and natural resources to achieve meaningful living. According to Benaim and Raftis, social sustainability is challenging since it appears to have a complicated and dominating social component (Benaim et al., 2008; Saner et al., 2020).

In contrast to the financial and environmental systems, the dynamics within the social structure are very intangible and challenging to describe because their flow and phases are so easily noticeable. Civil rights, gender equity and inclusivity, citizen participation, and the rule of law are just a few of the many issues that, in the opinion of Gray and Guo, fall under the umbrella of social sustainability (Gray, 2010; G. C. Wu, 2017). These issues all support social peace and stability, which are prerequisites for sustainable development.

Environmental sustainability is the ability of the natural environment to sustain human life while remaining robust and productive. Environmental sustainability is linked to ecosystem health and the natural environment's carrying capacity (Brodhag & Talière, 2006). The underlying premise is that natural resources cannot be depleted any quicker than they can be replaced and that waste cannot be produced any faster than it can be removed by the environment (Diesendorf Mark, 1999; Evers, 2018). This is done so that equilibrium can be preserved within the bounds or restrictions of the earth's systems. Environmental sustainability is a conservation idea that calls for meeting present-day and future generations' resource and service needs without jeopardizing the health of the ecosystems that provide for those needs. The guiding ideas for an environmental sustainability approach are as follows: Preserving both energy resources and biodiversity is known as biodiversity conservation. Social needs are the availability of necessities for the present and future generations, including goods and services. Support fair trade, local employment, and raw material environmental qualities. Regenerative capacity: Prevent the natural resource depletion by limiting the pace at which renewable resources are harvested. Support recycling and reuse initiatives to cut costs, waste, and emissions while enhancing the effectiveness of your products. Limitations on the use of nonrenewable resources and waste production: The human economic system should not exceed it carrying capacity, emissions should not exceed the capacity of the ecosystem to absorb them, low-impact transportation should be given priority, and effective decisions should take environmental quality into account (Morelli, 2013).

1.3. Sustainability In The Built Environment

1.3.1. Global And Indian Context On Sustainable Development

In 2018, the most significant portion of both global final energy usage (36%) and energy-related CO_2 emissions (39%) came from building construction and operations (IEA, 2019). In India, urbanization leads to an expansion in towns and cities and a rise in the population of urban regions. In India, where there are 121 million people, 37.7% reside in urban areas, a steadily increasing percentage (Chandramouli, 2011). Urban population growth necessitates more structures for people to live, work, and engage in, leading to more facilities and a predicted increase in electricity demand (Shandilya N & Ghorpade, 2019). India's urban population is expected to increase to 590 million by 2030, from 290 million in 2001 to 378 million in 2011 (CENSUS OF INDIA, 2019).

In 2017, 275 million households were expected to exist in India and rise by 328 and 386 million in 2027 and 2037, respectively. In the next ten years, the residential sector floor area is expected to increase from 15.3 billion square meters in 2017 to 21.9 billion square meters (NITI Aayog, 2011). The building industry contributed 8.04% of India's GDP in 2014–15; by 2025, it is predicted to increase to 16.74% (GBPN, 2014). By 2030, it is anticipated that the total floor space of buildings will expand by approximately 400% and that 20 billion m^2 will be added to the built environment (Kumar et al., 2010). However, the lack of energy efficiency measures and insufficient construction details offer considerable potential for energy savings, both in demand and consumption. India must immediately create energy-efficiency strategies centered on the residential sector to stop the current trend of unsustainable rising energy demand.

Building and construction have significant direct and indirect environmental implications. The services use energy, water, and other supplies, generating waste and emissions during pre- and post-construction, renovation, and demolition. Building standards and codes, certification systems, policies, and green rating systems have been developed and implemented worldwide to minimize environmental impact through sustainable design (Vierra, 2019). Creating more sustainable urban development patterns offers a possible resolution for the significant problems experienced in metropolitan areas worldwide. Since the Brundtland Commission publicized "Our Common Future" in 1987, sustainability and sustainable development have become more commonly connected with cities (Brundtland, 1987).

Additionally, experts contend that by focusing on urban sustainability, humanity may substantially impact creating a more sustainable globe (Glaeser, 2011; Owen, 2009). Many rating systems have been developed and applied worldwide to encourage sustainable development. For example, India has sought to improve energy efficiency through mandatory building codes, standards, and voluntary rating programs for buildings and products. With limited resources, sustainable development assists in determining a suitable answer to many settlements, such as physical, cultural, environmental, and economic advancements. Because it is built using local resources and methods with little waste, the vernacular architecture reflects the core of sustainability. The culture and its importance in the local and regional terrain are reflected in the vernacular architecture. Sustainability improves the quality of life by integrating the three significant aspects: environment,

and social and economic features of any built environment, thus becoming a part of tangible and intangible cultural identities (Taha, 2005). The tremendous range of climate, topography, and culture worldwide influences vernacular architecture. Environment, building techniques, use of materials, and cultural translations in a given region have influenced how vernacular buildings have changed over time. Understanding and using characteristics in traditional vernacular architecture in new structures have benefits. Vernacular Architecture has always been a method of building locally in response to a region's cultural, social, and microclimate. With the advent of better equipment and the expertise of local craftspeople, it has progressed. Vernacular architecture is not static; it responds to the changing culture and environment. It is a regional native that contributes to a community's and environment's long-term viability. There is a need to analyze the vernacular's position in changing attitudes toward the built environment (Dayaratne, 2018; Oliver, 1997, 2007a; Rapoport, 1969a). Brunskill suggests a classification system for vernacular structures based on their intended use. Domestic arrangements, such as private residences, rest houses, and leisure houses, are designed for living purposes (Brunskill, 1978). Traditional design concepts focus on space's function, energy efficiency, human comfort, aesthetics, and economic feasibility, all while considering and adapting to the local environment and culture (Foruzanmehr & Vellinga, 2011a).

The built environment has an impact on resource use. Estimates are that a significant proportion of world's resources are used for building and construction. Building and construction requires 40% of global energy, produces 40% waste, emits 30% of GHG emissions and uses 12% of the fresh water while employing about 12% of the workforce (UN Environment 2017, UNEP-SBCI 2016). According to Seto et al (2014), urban areas are estimated to consume between 67% and 76% of global energy and generate approximately three quarters of global carbon emissions, of which buildings and other infrastructure constitute a significant proportion as cited by Ness and Xing (2017). The developing economies are in a state of rapid city building as they are catching up with the developed world concerning urbanization.

Circular economy may be defined as a 'regenerative system in which resource input and waste, emission and energy leakage are minimized by slowing, closing and narrowing material and energy loops. This can be achieved through durable design, maintenance, repair,

reuse, remanufacturing, refurbishing and recycling (Geissdoerfer et al, 2017). Adopting circular economy approaches in a high-growth, high-waste sector like the built environment presents a tremendous opportunity for businesses, governments and cities to minimise structural waste and thus realise more excellent value from built environment assets. In a circular economy, renewable materials are used where possible, energy is provided from renewable sources, natural systems are preserved and enhanced, and waste and negative impacts are designed out. Materials, products and components are managed in loops, maintaining them at their highest possible intrinsic value (Ellen Macarthur, 2018). According to a report by UNEP (2006), in its most basic form, a circular economy can be loosely defined as one which balances economic development with environmental and resource protection and in this form; it appears to be inseparable from industrial ecology, and close to the three pillars (economic, environmental and social) of sustainable development. (Murray et al, 2017, p. 373). However, circular economy needs some level of societal engagement to put into practice. Other barriers are financial, structural, operational, attitudinal and technological (Ritzen & Sandstrom, 2017). Keeping circularity in mind, the building and construction industry must move from short to long term thinking. It needs to consider design for deconstruction, be innovative both in terms of design and supply chain considerations including non-linear financial models, use business as usual tensions between flexibility and durability, utilize new models of consumption and production where collaboration is the underpinning platform for producing outcomes.

1.3.2. Vernacular Architecture And Sustainability

Buildings of and for the people are often called vernacular structures (Oliver, 2007b). The sustainability of vernacular architecture links to structures that are more considerate of the environment. Users simultaneously create and build in vernacular architecture. The people may learn from the most resilient type of architecture—the vernacular traditions—when "sustainability" is predominant in architecture and design language (Oliver, 2007b). In vernacular architecture, sustainability-based research is often seen as an alternate method of constructing structures based on environmental conditions (Singh et al., 2009).

Housing might be viewed as a physical place that supports human consciousness. Housing refers to spatial things that satisfy not only people's physical requirements but also their emotional, social, and cultural needs (Mallett, 2004). The standard of living is significantly influenced by sustainable housing. Applying the principles of environmental preservation, economic efficiency, social inclusion and involvement, and cultural appropriateness will boost housing benefits. Sustainability-based research in vernacular architecture is typically viewed as an alternative technique for developing structures depending on environmental circumstances (Singh et al., 2009). Vernacular Architecture has always been a method of building locally in response to a region's cultural, social, and microclimate. One of the earliest attempts to create a thorough optimization model for energy accounting in home construction in India was made in the study titled "Energy efficiency and building construction in India" (Tiwari, 2001).

Leading individuals like Rudofsky, Rapoport, and Oliver have focused their research on the concept of vernacular architecture, and their methodology highlights the significance of anthropological and cultural factors in the development of vernacular architecture (Rudofsky, 1987)(Oliver, 1997)(Rapoport, 1969b). Until the Industrial Revolution, vernacular architecture remained the most common form worldwide. However, after the 1950s, a worldwide form of post-World War II modernism gradually replaced them (Guengerich, 2014; Komez Daglioglu, 2016). Vernacular architecture is a lesser-known and less-researched area focused on holistically architectural traditions and practices that are economical, environmentally responsible, and culturally appropriate. The vernacular design employs low-energy ideas and materials that are frequently economical and socially acceptable (Wahid, 2012). Although vernacular resources, technologies, or forms are frequently appropriate and sustainable, they may be functionally limited due to altered cultural, social, and technological settings. According to Foruzanmehr and Nicol, research must critically and methodically evaluate traditional technologies' performance. To understand how they might be improved upon and integrated to produce fully sustainable dwellings for the twenty-first century (Foruzanmehr & Vellinga, 2011b).

With the shift in global awareness regarding the utilization of energy and other resources, practicing architects now have the challenge of designing environment-conscious projects (Cox, 2009; Friedman, 2012; Wines & Jodidio, 1998). Due to this new duty, there has been a logical

shift away from the erroneous predilection for opulent, institutionalized building forms and toward more natural, modest, yet energy-efficient indigenous styles. The local methods of construction also take advantage of the users' understanding of how structures can be efficiently structured to support cultural preservation and traditional knowledge (Oliver, 2003; Rapoport, 2005). Given that local vernacular construction styles have shown to be energy-efficient and "green," refined by local resources, location, and climate, many practitioners are also motivated by these architectural traditions (Curtis & Curtis, 1996; Fathy, 1986; Lewis, 2014). Astonishingly little technology-based study on vernacular architecture has been done outside of performance-based examples, despite differences in vernacular architecture worldwide. The usual conceptions of "traditional" and "modern" in the language of architecture are one of the causes of constraint.

The benefit of vernacular architecture is that it integrates structures into different environments, resulting in a harmonious relationship between the surrounding landscape, the built environment, and the inhabitants (Brown & Maudlin, 2012; Sayigh & Hamid Marafia, 1998). The sustainability of vernacular architecture links to structures that are more considerate of the environment. To maintain society's survival, the users must adopt sustainable growth strategies that preserve the natural world's ecological balance. Most academics concur that vernacular architecture is a tried-and-true example of the sustainable building regarding social, economic, and environmental factors. However, as seen by the contemporary building sector, buildings created and assembled using modern technology continue to predominate. Vernacular construction was designed to be completely passive. Nevertheless, several investigations have revealed that the traditional design was occasionally unable to offer a suitable environment in the face of extreme weather (Gou et al., 2015; Huang et al., 2017; Nguyen et al., 2011; Ooka, 2002; Prasetyo et al., 2014).

Vernacular architecture demonstrates a resource-conscious and environmentally sustainable approach to building local homes in many parts of the world. Future architects and building designers must first understand the history of employing these methods as a well-balanced strategy to reach the highest level of environmental efficiency. In vernacular architecture, sustainability-based research is often seen as an alternate method of constructing structures based on environmental conditions (Singh et al., 2009).

In general, a family's identity, cultural and social needs, and the specific needs of each space are reflected in the physical characteristics of their home. As a result, each room in the house has a purpose (Goethert R, 2010). Thus, vernacular architecture offers essential information for comprehensive studies on the connection between environmental and cultural sustainability. As a result, embracing a place's sociocultural and regional environmental circumstances is necessary to fulfill local demands for an integrating resilient built environment. Vernacular architecture has been the subject of numerous studies. Indeed, research resources imply them as a learning source from which contemporary concerns can be handled if those lessons relate to a cultural context, technology, and bioclimatic principles (Balbo Riccardo, 2013; Hărmănescu & Enache, 2016).

However, researchers rarely attempt to adapt vernacular features for contemporary use and give little attention to questions of applicability or practicality (Foruzanmehr & Vellinga, 2011b; Songel, 2020). Vernacular architecture has also sometimes been viewed as only a romantic expression or a relic of the past. To attain the peaceful coexistence of humans and the environment, an eco-cultural approach to sustainable design advocates for advancements and progresses in the ecological, social, and cultural spheres (Vellinga & Oliver, 2013).

Instead of attempting to transform experts into practicing anthropologists, a socio-cultural approach encourages greater accountability and context awareness. Additionally, decision-makers who are experts or professionals should not be the only ones responsible for cultural and ecological tolerance. To be accepted in a long-lasting, culturally and socially meaningful fashion, it needs to involve the building's occupants. The mechanism required to create a socio-cultural design model is shown in Figure 1.2 as follows.

Vernacular architecture is used as a model by a sociocultural strategy to influence and be consistent with the area's current building design practices. Furthermore, a workable plan for ensuring sustainability and crucial regionalism is required. Modernity and technological progress are not opposed from an eco-cultural perspective. But it strives to create sustainable coherence and a more vital link between traditional, modern, and sustainable architecture. The inputs employed in the filtration process would significantly impact the outcome and effectiveness of this integration process. Depending on the situation, the built environment will alter and engage with these factors

differently (Figure 1.2). According to the input, if the filtration procedure did not consider all contextual aspects, one of three outcomes could result:

- In the first case, the design process focuses less on environmental sustainability and emphasizes vernacular and regional architectural design or socio-cultural factors. The end outcome would be a regionalized design that was not environmentally sustainable. When vernacular architecture is used exclusively for sentimental reasons, it may not always be able to satisfy all socio-cultural needs.

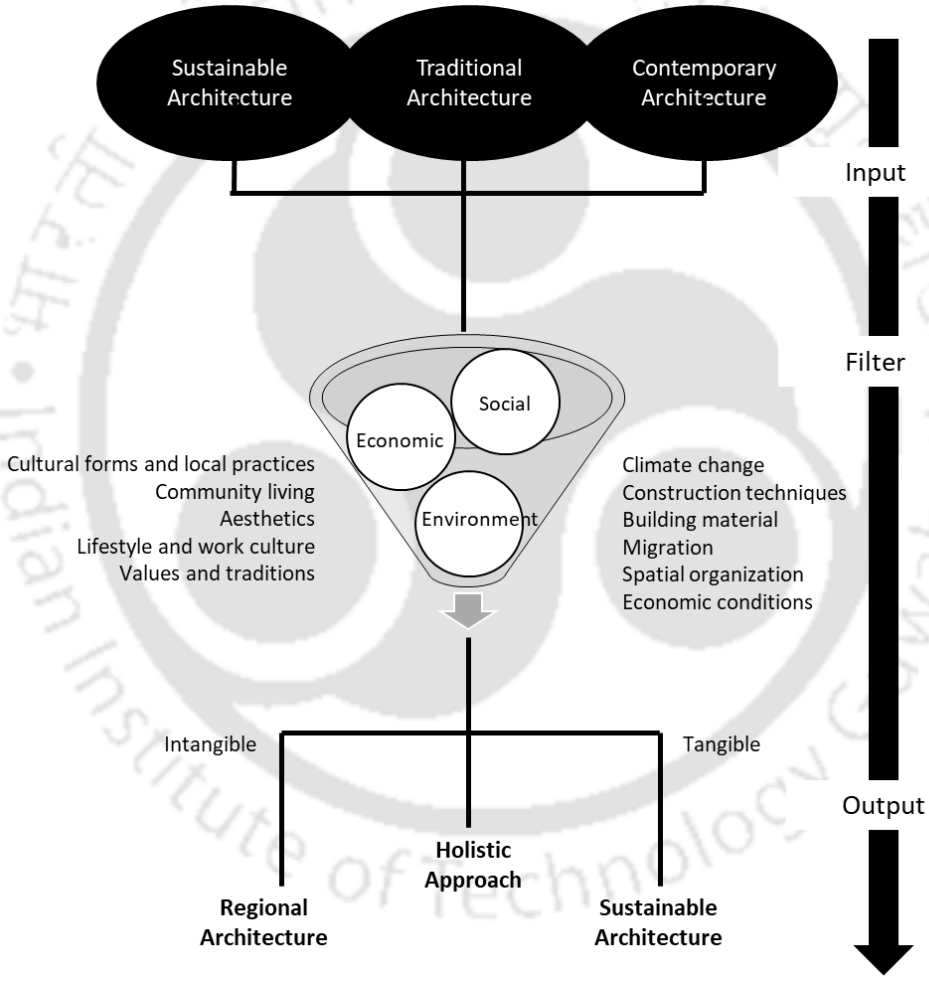

Figure 1.2 Adopted Socio-cultural Model *(Heath, 2009)*

- In the second case, more obvious environmental metrics are used, or sustainability is prioritized with little consideration for sociocultural context. Although the emerging architecture might be

environmentally friendly in this situation, it would not be appropriate for its human surroundings. Social and cultural practice conflicts may occasionally impact the project's environmental state because of structural changes or unforeseen user behavioral norms.

-The third scenario balances the three sustainable, traditional, and contemporary architecture themes within that setting by considering most of the crucial regional influences.

Several underlying factors have also contributed to the transition and transformation of vernacular forms, like rapid population growth, industrial and economic development, rising demands, technological interventions, and the need for housing and other buildings. The phenomena of vernacular settlement change are a recurrent occurrence. The vernacular speech continuously examines and challenges the concepts of change and continuation. It should be noted that as the social, political, cultural, and economic environments change, so do the vernacular settlements. To adapt to the changes and preserve continuity, grasping and observing vernacular is necessary. The mechanisms and circumstances causing these alterations are concerning and provide valuable data for studies on transformation.

Residential structures/houses are the finest places to study transformational changes since they are the most apparent manifestation of altering beliefs, values, and lifestyles. To comprehend the changes and their effects on the sustainable development of the built environment, it is equally crucial to research the environment. Different regions experience alterations to varying degrees. These alterations result from nostalgia for the way of life in what was once considered indigenous vernacular homes. Urban and rural areas experience different stages of transformation. Because industrialization and infrastructure development are occurring more quickly in metropolitan areas, the amount of regional and traditional architecture is declining. In rural areas, where transformation is slow, vernacular architecture coexists with new buildings and a few structures in the middle of their development. Numerous subcategories can be used to classify the type or extent of changes in vernacular architecture. Among them are Normative transformation, partial or intermediate transformation and total transformation, which can be seen in detail in figure 1.3.

Concern has been raised about changes to vernacular architecture since they result in the loss of indigenous knowledge, culture, and social values. Studying these changes is necessary to address

the issues of preserving and restoring vernacular villages and areas. The use of materials, the employment of construction methods, the socio-cultural impact, the economic status of the persons within the society, and the climate change impact are the numerous characteristics of the architectural form that need to be documented and evaluated to research transitions. Building regulations are required to regulate and practice modifications in the built environment.

1.3.3. Social And Cultural Aspects In Buildings

Social defines human society, the interaction of individuals and groups, or the welfare of human beings as community members (Merriam-Webster, 2022b). Social sustainability was initially introduced as a part of the sustainable development concept in the Brundtland Report (Brundtland, 1987). During the 1992 Rio Conference, social sustainability is defined as the right to a decent living, inter or intragenerational, worldwide social justice, and local engagement in sustainable development processes. Bostrom and Davidson suggest social sustainability, arguing that any endeavor to establish socially sustainable societies must first define the "type of society... we want to sustain" (Boström, 2017; Davidson, 2010). Jabareen connects urban planning and design principles, including compactness, mixed-use, density, sustainable transportation, and greening, to social sustainability results (Eizenberg & Jabareen, 2017). Physical characteristics related to sustainability are listed by Dempsey et al. and are fundamental and quantitative, making them easy to assess for effective planning (Dempsey et al., 2011).

Similarly, culture defines as the set of shared attitudes, values, goals, and practices that characterizes an institution or organization and the characteristic features of everyday existence shared by people in a place or time (Merriam-Webster, 2022a). Cultural sustainability is a development approach that preserves all cultural assets, including minority languages, traditional practices, artworks, artifacts, and historic structures and sites (UNESCO, 2015). The literature on cultural indicators can be outlined at least as far back as the early 1970s as sources of income and employment, including at the local level, cultural infrastructure, cultural and creative industries, sustainable cultural tourism, and cultural heritage all contribute to inclusive economic growth (Gouiedo, 1993). Hence, it helps improve living conditions, foster community-based economic growth, and empower individuals (UNESCO, 2015).

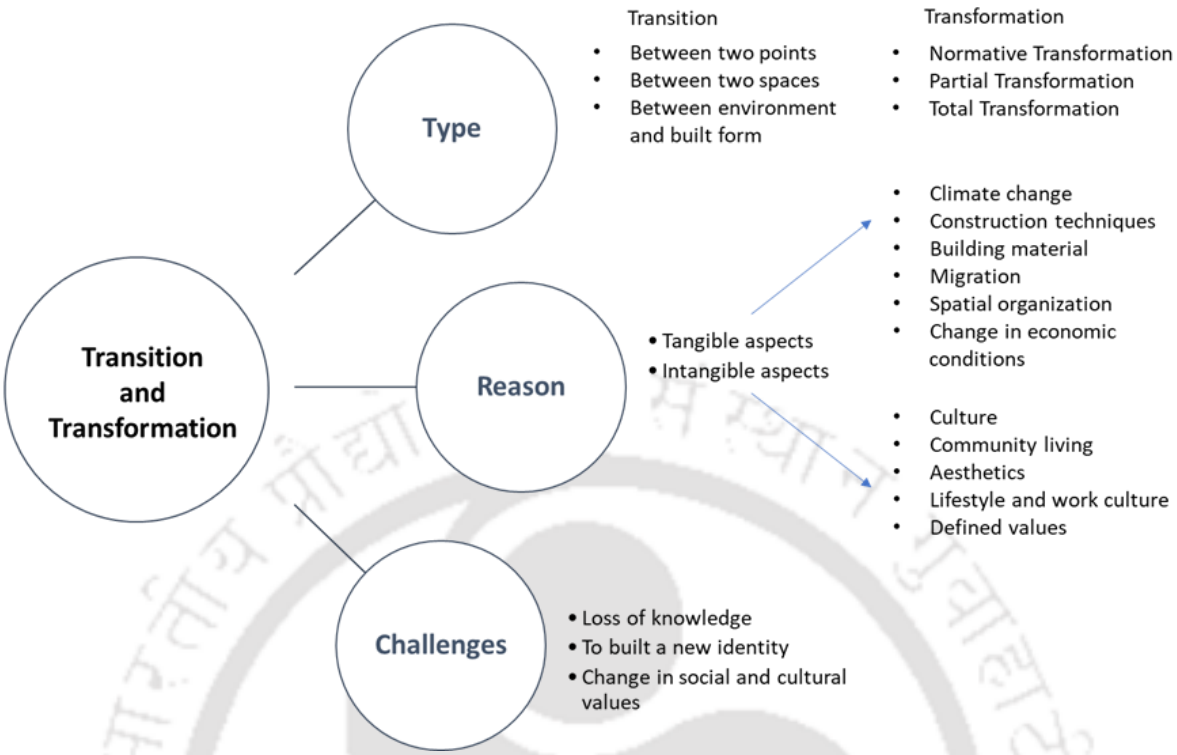

Figure 1.3 Transition and Transformation in Vernacular Architecture

Culture is what makes us who we are and forms our identities. There can be no long-term progress without culture. The U.N. General Assembly adopted the "2030 Agenda for Sustainable Development" in September 2015, including 17 bold, universal goals to transform our world (UNESCO, 2015). Most of the Sustainable Development Goals (SDGs) recognize the role of culture, including those focusing on quality education, sustainable cities, the environment, economic growth, sustainable consumption and production patterns, peaceful and inclusive societies, gender equality, and food security, according to UNESCO (UNESCO, 2015).

From the Brundtland Report and Agenda 21, urban nature has grown for social, cultural, and environmental reasons (United Nations, 1992a). Culture comprises a natural dimension as an ensemble of real vectors of social life. This dimension must be resurrected to strengthen and make culture's role in sustainable development more tangible(United Nations, 1992a). Socially sustainable communities are equitable, diversified, interconnected, and democratic, promoting a high quality of life. Chiu has also focused on social sustainability and presented it from three interrelated perspectives: development-oriented, environmental, and people-oriented (RLH Chiu,

2003). Additionally, Oliver and Rapoport demonstrated that the tangible and intangible markers are integral to developing conventional and vernacular construction and must be considered from a regional and socio-cultural perspective (Oliver, 2007a; Rapoport, 1969a).

1.3.4. Sustainability Assessment Practices

The term "sustainability assessment" comes from the Brundtland Report, published during the United Nations meeting in Rio de Janeiro in 1992. Sustainability was established as a measurable development element in its Agenda for the Twenty-First Century (Agenda 21) (United Nations, 1992a). Sustainability assessment is the methods and procedures used to evaluate the potential effect of actions before they are carried out. This allows decision-makers to make more sustainable decisions (Morrison-Saunders et al., 2014). The goal of sustainability assessment is to (1) improve understanding of the concept and its context-specific interpretation; (2) incorporate sustainability challenges into decision-making by measuring impacts; and (3) encourage sustainability initiatives (James et al., 2014).

Sustainable development and its assessment are crucial for achieving sustainability and have received extreme attention (Mahmoud et al., 2019). Sustainability evaluation integrated assessment, integrated sustainability assessment, and impact analysis are some of the words and approaches used (Sala et al., 2015). In addition, evaluation approaches are being utilized to aid policymakers and have become standard planning practices. As fresh perspectives on impact assessment for planning and decision-making on sustainable development, "Integrated Assessment" and "Sustainability Assessment" are proposed (Ameen & Mourshed, 2019). Sustainable building evaluation arose a decade ago to measure and enhance the built environmental performance and sustainable goals (Ameen & Mourshed, 2019). Measuring and assessing sustainability remains a big problem and a source of contention over what it entails and how to carry it out. It incorporates cross-disciplinary elements and human value-based metrics (Hák et al., 2016). There are no universally acknowledged indicators for describing the natural habitat and its connections with sustainable development's social, cultural, and economic components (Ahmad & Thaheem, 2017). This dispute could be due to the absence of a universally recognized definition of the concept that considers social, cultural, and human context

factors, as compared to approaches that focus on tangible aspects and metrics of sustainability or when integrating quantity and quality factors (S. R. Wu et al., 2016).

- Systems for evaluating sustainable buildings

Building rating systems are multiple criteria-based credit evaluation techniques that award points for several pre-determined indicators. These indicators include various categories influencing overall building sustainability (Ameen & Mourshed, 2019). Sustainable and green building rating systems are commonly used evaluation systems for the building and urban environment (Mattoni et al., 2018). These systems are intended to establish a method for evaluating various performance measures during building design, pre-and post-construction, operations, maintenance, and, in certain situations, deconstruction (James et al., 2014). They test a building's performance consistently and harmoniously using pre-established standards, regulations, parameters, or criteria (Awadh, 2017). Scoring techniques are defined based on four primary components to establish specific rankings and levels in rating systems (Doan et al., 2017). Figure 1.4 depicts the categories of the scoring systems.

End-users and other shareholders in the construction procedure benefit greatly from criteria and category-based assessment methodologies. They promote significant improvements in the building's overall performance, stimulate the adoption of construction solutions better suited to its intended use, and promote better knowledge and communication of user needs. They also help integrate environmental, social, functional, and cultural problems more effectively than quantitative-based techniques like LCA (Teng et al., 2018).

- Current building rating systems

Building assessment methods are designed to address sustainability in various building categories, such as commercial or residential buildings, at multiple scales, ranging from a single building to a neighborhood, community, or an entire city (Bernardi et al., 2017). According to Ali and Al Nsairat, the greenest building rating systems are BREEAM in the United Kingdom, CASBEE in Japan, LEED in the United States of America, and GB Tool in Canada (BRE, 2017; IBEC, 2007; USGBC, 2020). However, these tools are frequently chastised for a lack of understanding of

economic and social issues. Also, the sustainability criteria in some of the tools are not prioritized for decision-making.

With the launch of BREEAM in the 1990s, the notion of environmental green building evaluation rating and certification methodologies was established (BRE, 2017). As a result, several countries have realized the value of such a tool in supporting and providing additional perspectives to construction developers and other stakeholders in assessing their projects regarding sustainability and their development principles. The progress of building rating systems in terms of both measurable and qualitative components of sustainability has been considerable since the advent of BREEAM.

Green or sustainable building evaluation methods are now widely regarded as a critical component of long-term development in the built environment (Awadh, 2017). Many government and non-government organizations have suggested sustainable building assessment techniques throughout the world, including LEED (USA), CASBEE (Japan), and SB Tool (international), as well as Indian grading systems (GRHIA and IGBC) (BRE, 2017; GRIHA, 2019; IBEC, 2007; IGBC, 2019; iiSBE, 2007; USGBC, 2020). Domestic and international legislation and the business requirement for ecologically evaluated and sound goods have influenced these methodologies (Haapio & Viitaniemi, 2008). The evaluation techniques adhere to the UN's three sustainability sectors and goals. The details of these assessment methods have been discussed in depth in chapter 2.

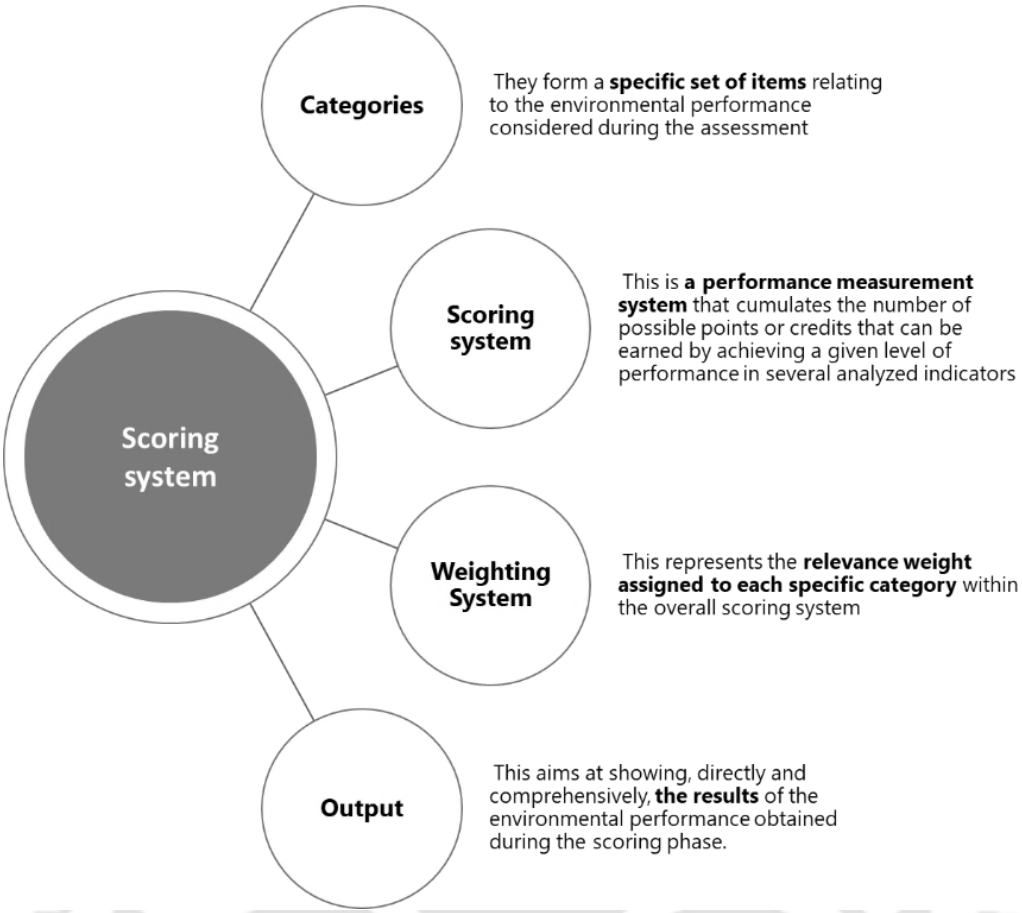

Figure 1.4 Categorization Of Scoring System For Grading.

The Green building tools influence sustainability metrics related to environment, economic and social aspects , thus aiming to improvise over all building performance. From a stakeholder point of view, green buildings are proven to make business sense – they are energy efficient, consume less water, minimize waste, and decrease operational costs. Through sustainable design, construction and operations, green buildings are climate-resilient, consume less water, optimally use energy, conserve natural resources, generate less waste, and enhance biodiversity. As a result, they ensure a better liveability quotient by providing better ventilation, adequate daylight, superior air quality, and overall well-being. From an economic viewpoint too, green homes reduce the operating costs of buildings, improve productivity and efficiency, and provide higher ROI, higher asset/rental value, rebates on property taxes, and savings on recurring costs like electricity, water, medical, etc., bills Several governing bodies in India have also offered incentives on adoption of green building rating.

The Building Research Establishment created the Building Research Establishment Environmental Assessment Method (BREEAM) to establish best practices in sustainable design, construction, and management (BRE, 2017). BREEAM employs a weighing and assessment methodology that includes comparing indicators to set standards and levels of performance and awarding credits in 10 categories. Each area has several criteria, including pre-weighted points that might be cumulative or based on performance under EIA guidelines established by the UK government and the European Union (EIA-UK 2009). The evaluation scale is passed, good, very good, excellent, and outstanding. These credits are combined to generate a single overall score (BRE, 2017).

The valuation procedure in BREEAM is categorized into three stages aligned with pre-construction, like planning and design during the construction of new projects. The corresponding scores are obtained when a building is classified as green and passes or surpasses a baseline indication. The final BREEAM ratings are then used to determine the ranking grade. The max credit points are 150. Evaluation stages are marked according to percent: Outstanding (≥85%), Excellent (≥70%), Very Good (≥55%), Good (≥45%), Pass (≥30%), and Unclassified (<30%) (BRE, 2017).

LEED is a third-party green building certification program globally known and adopted for designing, constructing, and operating high-performance green constructions (USGBC, 2020). It started as an independent initiative by US Green Building Council in 1998 to evaluate and assess different types of buildings. LEED (Leadership in Energy and Environmental Design) is globally widely used green building rating system. It was the Indian Green Business Center (IGBC), under the Confederation of Indian Industries (CII), that facilitated the LEED rating of the United States Green Building Council (USGBC, 2020). The certification covers all building types and phases, including new construction, interior fit-outs, operations and maintenance, and core and shell. It has also released some country-specific editions. The most recent LEED version, LEED v4.1, lifts the bar on construction requirements to consider energy efficiency, water conservation, site selection, material selection, daylighting, and waste reduction (USGBC, 2020). Combining the most relevant terminology from the BD+C and all other residential-focused grading systems with the goals of the residential market, it introduces a novel approach to residential projects. The author has considered here the version specifically adapted for India. The LEED v4.1 Multifamily

Residential grading system has four main objectives: establish leadership, make goals more attainable, track achievement, and grow the market (USGBC, 2020).

The Japanese Sustainable Building Consortium created the Comprehensive Assessment System for Built Environment Efficiency. This approach may be used at different phases of a building's life cycle (design, new construction, existing buildings, and renovation projects) (IBEC, 2007). The CASBEE rating system for construction projects is distinct from other rating systems. It is accomplished using a metric known as Building Environmental Efficiency (BEE). BEE is calculated as the ratio of two metrics: built environmental quality (Q) and built environmental load (BEL) (LRQ evaluates how the daily amenities for building occupants have improved within the perimeter of the virtual enclosed space. The negative aspects of environmental consequences that go beyond the immediate region are calculated by LR (IBEC, 2007). The three subcategories comprising the Q and LR scores, which range from 0 to 100, are determined using an assessment form. Each category (quality of service, on-site outdoor environment, internal environment, resources & material, off-site environment, and energy) has a corresponding weight (IBEC, 2007). Each category is given a score between one and five, with five representing the highest rating (the highest point of accomplishment). The score and rating can be shown in various ways, giving users further options for using the data.

IISBE manages SB Tool, a software application of the Sustainable Building Challenge (SBC) evaluation technique, which has been developed as the Green Building Challenge procedure since 1996 by a consortium of 14 nations. SB Tool is unusual because it was built from the ground up to represent other areas and nations' goals, technology, construction traditions, and cultural values (iiSBE, 2007). The SB Tool may be used for projects ranging from a single structure to a whole city and has been translated into various languages. Its approach al-lows for quickly adding local criteria and language and adjusting indicator weightings based on the area of priorities and specific conditions (IBEC, 2007). Site selection, project planning and development, environmental loadings, energy and resource consumption, interior environmental quality, building system functionality, and controllability, long-term effectiveness, and social and economic indicators are the seven factors that the tool examines. Individuals, society, and nature are pre-weighted in SB Tool, with values ranging from 1 to 5 (IBEC, 2007).

The Ministry of New and Renewable Energy, Government of India, and TERI developed GRIHA in 2005. It recognized the Green Rating for Integrated Habitat Assessment (GRIHA) as India's national rating system in 2007 for any finished structure [20]. It is a tool for assessing and rating a building's environmental performance. GRIHA v.2019 certifies all new construction projects with a built-up area of more than 2500 m^2 (excluding parking, basement area, and typical facilities). The projected outcomes determine a structure's worth on its lifespan (GRIHA, 2019). It is a three-tiered green building design evaluation method for grading facilities. The 34 criteria of the GRIHA grading system are divided into four sections: site selection and planning, resource conservation and efficient use, building operation and maintenance, and innovation. This version has considered user input, improved ease of implementation and acceptance, and other factors not considered in earlier editions (GRIHA, 2019).

GRIHA's goals align with the realization of SDGs, especially those that affect the scope of sustainable building development. GRIHA integrates various relevant Indian construction, energy, water, materials, and waste management codes to act as a tool to promote the implementation of these codes (GRIHA, 2019). Griha v.2019 is divided into ten environmental parts, subdivided into 29 standards, covering all the necessary parameters to consider when creating a "green building." The additional part of "innovation" is the rating system, which rewards project teams that make more effort to achieve environmental and social sustainability.SVAGRIHA is designed as an extension of GRIHA and is specially developed for projects with a floor area of less than 2500 square meters. SVAGRIHA can help plan and evaluate individual apartments, small offices, schools, motels, and commercial buildings. The evaluation includes only 14 standards, and the inter-face consists of a simplified calculator (GRIHA, 2019).

Envisioned in 2007, the Confederation of Indian Industry (CII), with the Indian Green Building Council (IGBC), created an exclusive rating system focusing on the design of green homes and launched it in 2009. The council provides various services, including creating a new green building rating system and certification services (IGBC, 2019). The rating system was designed to address national concerns and stimulate dwellings, including traditional Indian architectural techniques and current technological advancements. Green new/existing buildings, green residential societies, and green residences are included in the IGBC Green Building Rating Systems. It is a voluntary

and consensus-based approach that helps buildings become more efficient and environmentally friendly (IGBC, 2019).

Green Homes, developed by the Indian Green Building Council (IGBC), is the first rating system designed specifically for the residential sector in India (IGBC, 2019). It is founded on well-established energy and environmental principles and balances well-established procedures and new ideas. The system is intended to be both comprehensive and straightforward to use. Site Selection and Planning, Water Conservation, Energy Efficiency, Materials & Resources, Indoor Environmental Quality, and Innovation & Design Process are all covered by the IGBC Green Homes rating system. The International Green Building Council (IGBC) has also created a green building rating system for Affordable Housing and Green Residents (IGBC, 2019).

1.4. Chapter Conclusion

This chapter focuses on laying the foundation of sustainability and its pillars. The chapter establishes the global and Indian context on sustainability and the current energy and housing scenario. The section highlights the importance and need for sustainable development in the housing domain and mentions sustainability assessment methods in practice. This section helps build the context of a comprehensive study and contributes to framing research gaps and questions.

1.5. Research Background

The study aims to determine a way to more effectively integrate the physical and intangible aspects of housing for a socio-cultural-focused, sustainable development. The study highlights the negligence of socio-cultural indicators in most sustain-able design methods as most sustainability assessment tools (worldwide) appear to be biased toward physical attributes related to energy, environment, material, and re-sources. There is a need to cater to more sustainable housing that is socially and culturally appropriate for the transition to a low-carbon future. In most research regarding the sustainable built environment, the participation and feedback are limited to industry experts and exclude residents. The study presents a view of residents toward incorporating socio-cultural indicators and understanding sustainability. The study focuses on socio-cultural

sustainability: merging culture as the fourth pillar of sustainability/ as an extension of social sustainability. The study attempts to answer the following mentioned research questions.

1.5.1. Research Gap

- There is negligence of socio-cultural pointers in most of the sustainable design methods.
- Most sustainability assessment tools (worldwide) also appear biased toward physical attributes related to energy, environment, material, and resources.
- There is a need to cater to more sustainable, socially and culturally appropriate housing to transition to a low-carbon future.
- In most research regarding the sustainable built environment, the participation and feedback are limited to industry experts and exclude users and residents.

1.5.2. Aim, Objectives, And Research Questions.

Research Aim

To develop a holistic, sustainable design assessment framework and tool for housing.

Research Objectives

I. To focus on socio-cultural sustainability: Merging culture as 4th pillar of sustainability/ as an extension to social sustainability.

II. To find relevant socio-cultural indicators (tangible and intangible) that are user-defined.

III. To propose a balanced, sustainable design assessment framework.

IV. To translate the developed framework into an assessment tool with the help of existing green building guidelines and assessment methods.

Research Questions

I. R1. What are the indicators for social and cultural aspects of housing?

   a. Which social and cultural indicators are relatable?

   b. How do these socio-cultural indicators connect with the built environment?

   c. Which sustainable design assessment tools are available in developed and developing countries, and how have they integrated socio-cultural indicators?

   d. What is the user perception towards integrating socio-cultural indicators in housing?

   e. How to involve user and their participation in sustainable design assessment?

II. R2. How to incorporate socio-cultural aspects into green building assessment methods for housing?

III. R3. How to develop a holistic and balanced framework for sustainable design assessment?

IV. R4. How to translate the developed framework into a tool?

1.5.3. Scope Of The Study

The research began by building upon earlier studies of sustainable and modern architecture and its practices, emphasizing the occupant's context and how it affects establishing a sustainable environment to address the research problems and achieve the study's aims.

The study's scope, therefore, encompassed the following topics and areas:

- Social and cultural indicators: To identify, determine, review and validate social and cultural indicators from secondary research like research papers, global reports and other relevant data examined for Indian context related to built environment.

- Policy, codes, and sustainable design assessment methods: Practical and on-site approaches like methods and techniques developed for evaluating green buildings like rating systems,

policies, and regulations and involvement of their stakeholders are studied and reviewed for their suitability for applying to buildings and for integrating socio-cultural and context-based indicators.

- Development of DASH: To develop a design assessment framework and tool for sustainable housing, which will aid in both academic and practical application. The framework will support the integration of social and cultural indicators in the existing frameworks and tools and help translate the intangible factors into practical solutions.

1.5.4. Overview Of Research Methodology

The study focus on socio-cultural sustainability. The research fulfills its aim by distributing the agenda into four primary objectives.The study aims to determine a way to more effectively integrate socio-cultural-focused indicators for a holoistic sustainable development for housing. The study highlights the negligence of socio-cultural indicators in most sustainable design approaches. The study presents a view of residents toward incorporating socio-cultural indicators and understanding sustainability. Through secondary data analysis and data collection, the research determines to find relevant socio-cultural indicators that are user-defined. The developed framework is translated into a practical tool and which is validated later.Figure 1.5 outlines the fundamental research of the study along with the later outcome. The figure shows the overall outlook of the strategy involved in developing the framework and its translation into the tool.

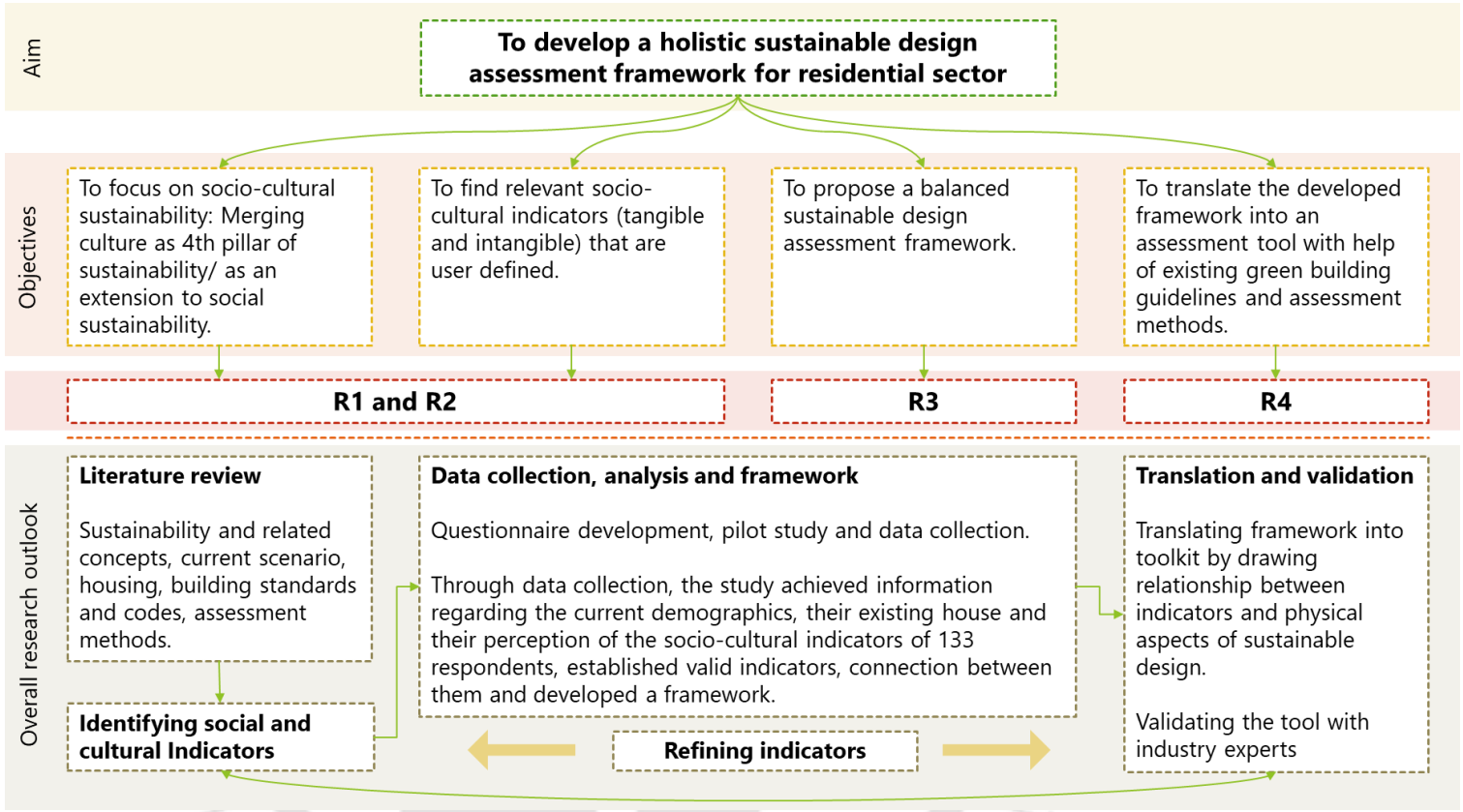

Figure 1.5. Research Outlook for DASH

Chapter 2

LITERATURE REVIEW:

Building Codes, Rating Systems, and Sustainability Indicators

2. LITERATURE REVIEW: Building Codes, Rating Systems, And Sustainability Indicators

2.1.Introduction

The literature study has three primary focal areas for review: sustainability, information about the Indian context on sustainability, and housing. For sustainability, the relevant regions are sustainability as a concept, its pillars, sustainability in the built environment, its assessment, and social and cultural indictors. Out of these topics, sustainability assessment in the national and global context is discussed in depth in the following chapter. The rest are covered in the introduction part. Regarding the Indian context, the national codes, policies, standards, and rating systems are covered and discussed in detail in this chapter. Understanding social and cultural indicators is also covered here, and the introduction chapter covers the outline. Details about housing are covered in the introduction chapter, although policies and reforms that drive them are covered here. Figure 2.1 showcase the literature study map for better clarity.

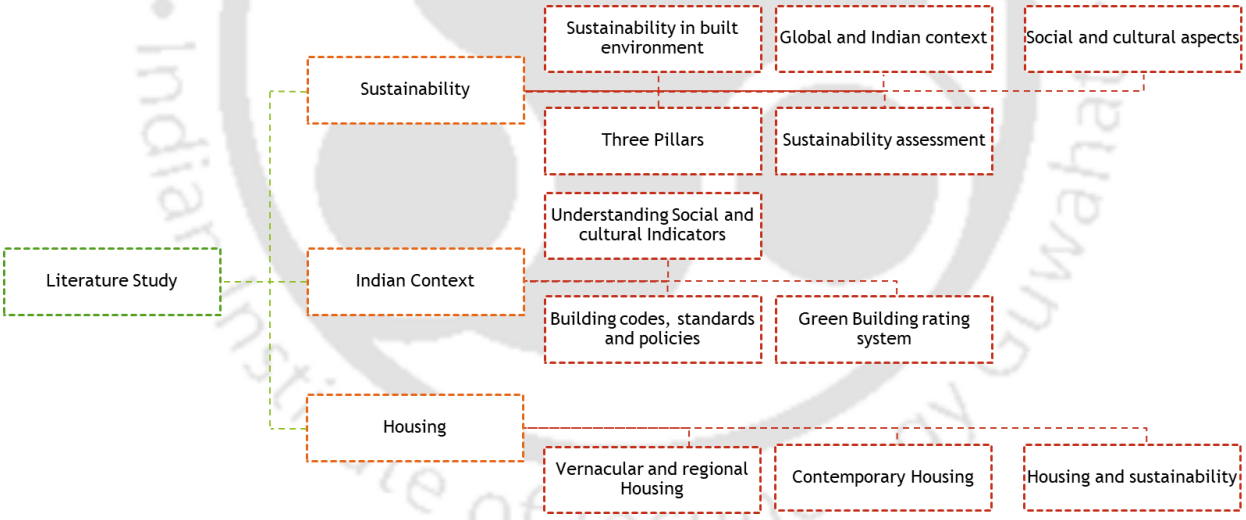

Figure 2.1 Literature Study Flow Diagram

2.2.Building Codes, Standards, And Policies

The first section focuses on India's policy outlook for housing and energy developed by the central government of India and other related reforms that drive these policies. The second section highlights the understanding of social and cultural indicators of sustainability through these policy documents, reports, and other literature reviews. The base of social and cultural sustainability has been discussed in previous chapters.

The Ministry of Housing and Urban Affairs is entrusted with the broad policy formulation, administration, and monitoring of the various housing and urban development schemes. Urban development is a State subject, and the Constitution (Seventy-fourth) amendment Act, 1992 has delegated many functions to urban local bodies(MoHUA, 2018). However, the Government of India plays a coordinating and monitoring role and supports various urban housing programs, urban livelihood missions, and overall urban development through Central and Centrally Sponsored Schemes. The Ministry facilitates resolving multiple issues relevant to the urban sector through appropriate policy guidelines, subordinate legislation, and sectoral program.

The government of India initiated the very first effort for energy conservation by introducing the Energy Conservation Act, published in the Gazette of India in October 2001. The Bureau of Energy Efficiency (BEE) was instituted in 2002 to implement EC Act(GoI, 2001). Further, the Government of India launched the first version of the Energy Conservation Building Code in 2007. EC Act was amended in 2010 with a further update of ECBC in 2017, restricted to commercial buildings. Recent developments such as revision in the National building code in 2016, Model building bye-laws in 2016, and ECBC -R (Eco Niwas Samhita 2018 for the residential sector) is set to potentially increase the overall impact on energy savings at the city level substantially (BEE, 2018; BIS, 2016; MoUD & GoI, 2017). The importance of energy and its effects on buildings have been recognized and addressed in fundamental building norms and green building certifications. These have been integral to central and state policies and apply to almost all types of buildings. The policies/codes below highlighted the importance of energy efficiency indirectly/indirectly dealing with energy and their role in respective areas.The governance structure for the state for housing is illustrated in Figure 2.2 below.

The government of India has three levels in its governance structure, i.e., central, state, and city level, which are merely responsible for the formation and implementation of rules and regulations. The following diagram, figure 2.4, explains the roles at each level following the aim. Also, the study titled "Energy efficiency and building construction in India "concludes with commendations for structural changes in energy and construction policy in India building construction to minimize energy consumption. The study highlights here as it was one of the first attempts in the research field to develop a comprehensive optimization model for energy accounting in house construction in India (Tiwari, 2001).

The Government of India (GoI) has been developing policies and programs to guide urban planning and energy management mainstreaming. According to the Constitution of India, urban policy, planning, and housing are state subjects. However, the central government has played a proactive role in housing matters by formulating policies and pro-grams, giving directives to the state, and allocating funds under the five-year plans (MoHUA, 2018). To meet citizens' energy needs and reduce carbon emissions, the Indian Government has adopted a two-pronged approach, i.e., focusing on supply and demand. On the generation side, greater use of renewable energy, mainly solar and wind, is being promoted. On the demand side, efforts are being made to improve energy efficiency through various innovative policy measures within the 2001 Energy Conservation Law umbrella (GoI, 2001). Figure 2.5 represents the policy landscape for housing and energy. The governance structure of the state under the energy sector is illustrated in figure 2.3 below.

2.2.1. Overview Of Housing Policies And Other Reforms

The Ministry of Housing and Urban Affairs is entrusted with the broad policy formulation, administration, and monitoring of the various schemes relating to the nation's housing and urban development. The development of cities is a state responsibility, and the Constitution (Seventy-fourth) Amendment Act of 1992 assigned several duties to urban municipal governments (MoHUA, 2017). On the other hand, the Government of India coordinates and monitors numerous urban housing projects, urban livelihood missions, and overall urban development through Central and Centrally Sponsored Schemes. The Ministry promotes urban challenges through practical

policy guidelines, subordinate legislation, and sectoral programs (MoHUA, 2017). This section outlines the primary housing policies/schemes launched by the Government of India, which formulates the housing sector.

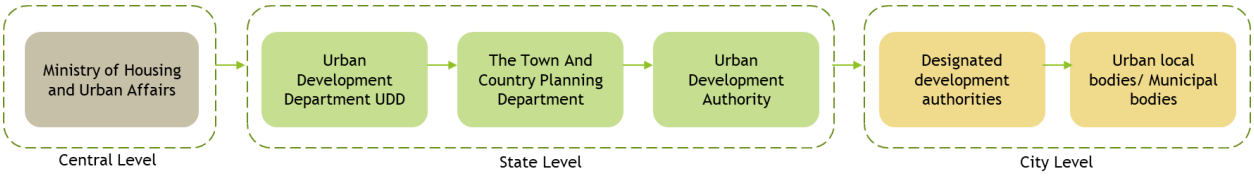

Figure 2.2 The Governance Structure For The Housing Sector.

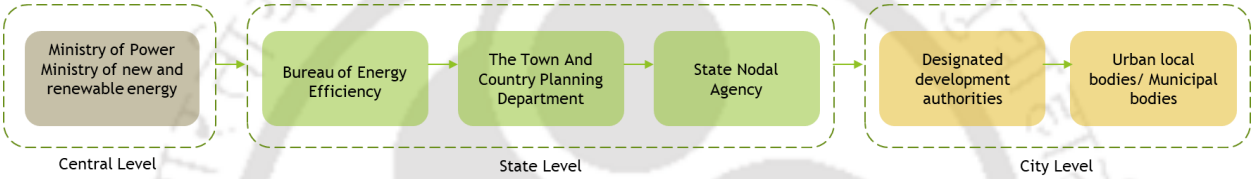

Figure 2.3 The Governance Structure For The Energy Sector

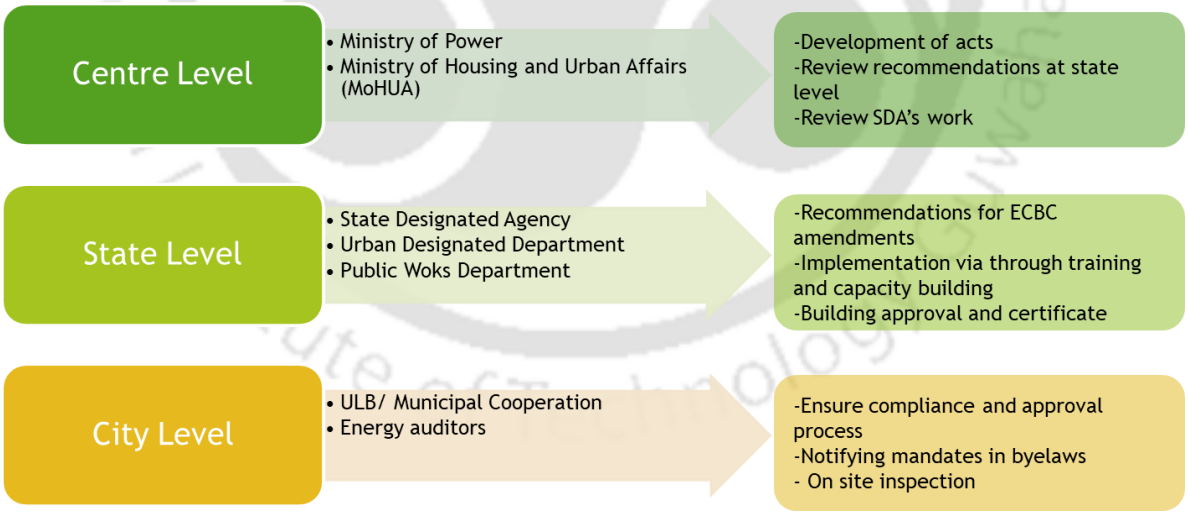

Figure 2.4 Governance Structure of India

The Ministry of housing and urban affairs announced the Jawaharlal Nehru National Urban Renewal Mission in 2005 as the first flagship scheme of this Ministry. JnNURM implemented by

has two components, e.g., Basic Services for Urban poor (BSUP) and Integrated Housing and Slum Development Programme (IHSDP), intended to develop slums through projects (MoHUPA, 2015). The Mission was initially for seven years, i.e., up to March 2012, which was extended to March 2014 to complete the already approved projects. In March 2013, the Mission period was extended by one more year, i.e., up to March 2015, to complete ongoing works (MoHUPA, 2015).

In 2007, the Ministry of Housing and Urban Poverty Alleviation announced the National Urban Housing & Habitat Policy, which aims to encourage various forms of public-private partnerships to achieve the objective of "Affordable Housing for All," with a focus on the urban poor. The Policy aims to encourage sustainable habitat development in the country to provide an equal supply of land, shelter, and services at affordable rates to all segments of society (MoHUA, 2007).

Pradhan Mantri Awas Yojana (Urban) was introduced by MoHUA, and launched in June 2015, ensuring housing for all in urban areas; it is a first-of-its-kind initiative designed to provide 'Housing for All' by the end of the year 2022. The Mission offers Central Assistance to implementing agencies via States/Union Territories (U.T.s) and Central Nodal Agencies (C.N.A.s) to provide homes to all eligible families/beneficiaries with the verified housing need (MoHUA, 2015a). The dwellings built under the Mission shall be planned and constructed to fulfill the structural safety standards of the National Building Code and other applicable Bureau of Indian Standards (BIS) norms. The houses under the Mission should be designed and constructed to meet structural safety requirements conforming to the National Building Code and other relevant Bureau of Indian Standards (BIS) codes (BIS, 2016).

The Government of India has established the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) to improve the quality of life for all, particularly the poor and disadvantaged, by providing basic civic facilities such as water supply sewage, urban transit, and parks (MoHUA, 2014). Another project launched by the GoI in 2015 is the Smart City Mission, which supports sustainable and inclusive communities that offer basic infrastructure and good quality of life to their inhabitants, a clean and sustainable environment, and the use of 'Smart' Solutions (MoHUA, 2015b). The Mission will be implemented through four verticals, giving beneficiaries, U.L.B.s, and State Governments. The Government of India introduced the RERA

Act in 2016, with all the Act's provisions coming into effect in May 2017. Every state is accountable for establishing a Regulatory Authority (RERA), which will administer all the real estate sector's activity and regulate and promote the development of Real Estate in the country (MoHUA, 2016).

The Government of India, along with the governments of the respective states, has taken several initiatives to encourage development in the sector. Housing for all led to the development of several initiatives launched by GoI. A Technology Sub-mission under PMAY (2015) facilitates adopting modern, innovative, and green technologies and building materials for better quality and faster construction (MoHUA, 2015a). In 2017 the Government of India, for under-construction housing projects and to improvise the affordable housing sector, the goods and services tax rates were revised to 5% from the effective rate of 12% and from 8% to 1% (MoF, 2017).

The World Bank creates an ease of doing business index, with higher scores indicating better, typically more straightforward rules for firms and more significant property rights safeguards. India climbed the ranks by making it simpler to do business in four of the report's ten areas of business regulation, including business incorporation, obtaining building permissions, resolving insolvency, and trade (World Bank, 2017). In 2017, the Government gave affordable housing infrastructure status, allowing these projects to benefit from reduced borrowing rates, tax breaks, and larger foreign and private money flows. Later in 2018, the Union cabinet approved the National Urban Housing Fund for Rs. 60,000 crores, situated in Building Materials and Technology Promotion Council (BMTPC), to facilitate raising requisite funds for PMAY (MoHUA, 2015a). Table 2.1 below showcases initiatives in the housing sector.

Table 2.1 Initiatives Under The Housing Sector

Initiatives	Year	Information	Remarks
Sub-technology mission under PMAY	2015	To encourage the use of contemporary, innovative, and environmentally friendly building materials and technologies to speed up and improve the quality of house construction. It will also make it easier to create and implement layout ideas and construction plans appropriate for diverse geo-climatic zones. It will also help states and cities implement disaster-resistant and environmentally friendly technology.	
Ease of doing business	2017	India is now ranked 63rd from 183rd among 190 countries in the ease of doing business index. India ranks 27th in dealing with construction permits, 22nd in getting electricity, and 154th in registering property.	
Reduction of G.S.T.	2017	To improvise the affordable housing sector, the Government of India cut the goods and services tax rates for under-construction housing projects to 5% from the effective rate of 12% and from 8% to 1% for affordable housing projects.	Service Tax Exemptions will be continued in G.S.T. as decided by G.S.T. Council Services for works about the Housing for All (Urban) Mission/Pradhan Mantri Awas Yojana (PMAY)
Infrastructure Status to affordable housing	2017	The union budget was announced with Transform, Energies, and Clean India, geared towards infrastructure growth and poverty alleviation. The funding provided affordable housing with infrastructure status. The initiative will enable the affordable housing projects to avail themselves of the allied benefits such as lower borrowing rates, tax concessions, and increased foreign and private capital flow.	
National Urban Housing Fund	2018	The Union Cabinet approved the creation of NUHF for Rs. 60,000 crores. The fund situated In Building Materials and Technology Promotion Council (BMTPC) will facilitate raising requisite funds until 2022 so that the flow of Central Assistance under different verticals of PMAY-U is maintained.	

2.2.2. Overview Of Energy Policies And Other Reforms

The Energy Conservation Act (E.C. Act) of 2001 was enacted to lower the energy intensity of the Indian economy (GoI, 2001). The Bureau of Energy Efficiency (B.E.E.) is a statutory entity within the Ministry of Power that oversees driving the economic development of energy efficiency through different regulatory and promotional tools. The Bureau of Energy Efficiency (B.E.E.) was established as a statutory entity at the central level in 2002 to support the implementation of the E.C. Act. The Act establishes regulatory mandates for equipment and appliance standards and labeling, energy conservation construction regulations for commercial buildings, and energy consumption guidelines for energy-intensive businesses (GoI, 2001). The Government of India created the Energy Conservation Building Code in 2007 to encourage energy efficiency in the building sector. The E.C. Act revised again in 2010, with the second update of ECBC in 2017, limited to the business sector. ECBC (Energy Conservation Building Code), introduced in 2017, applies to significant commercial buildings with connected loads of 100 kW and above or 120 kVA. ECBC (Energy Conservation Building Code), introduced in 2017, applies to substantial commercial buildings with connected loads of 100 kW and above or 120 kVA and above (BEE, 2017). ECBC focuses on the elements like building envelope, mechanical systems, and equipment such as heating, ventilating, air conditioning (HVAC) systems, interior and exterior lighting systems, electrical systems, and renewable energy. The code applies to the five climate zones found in India (Hot and Dry, Warm and Humid, Temperate, Composite, and Cold). Recent developments in the policies, such as revision in the National building code (2016), Model building bye-laws (2016), ECBC -R (Eco Niwas Samhita 2018), and guidelines by CPWD (2014) are set to increase the overall impact on energy savings potential (BEE, 2018; BIS, 2016; CPWD, 2014; MoUD & GoI, 2017).

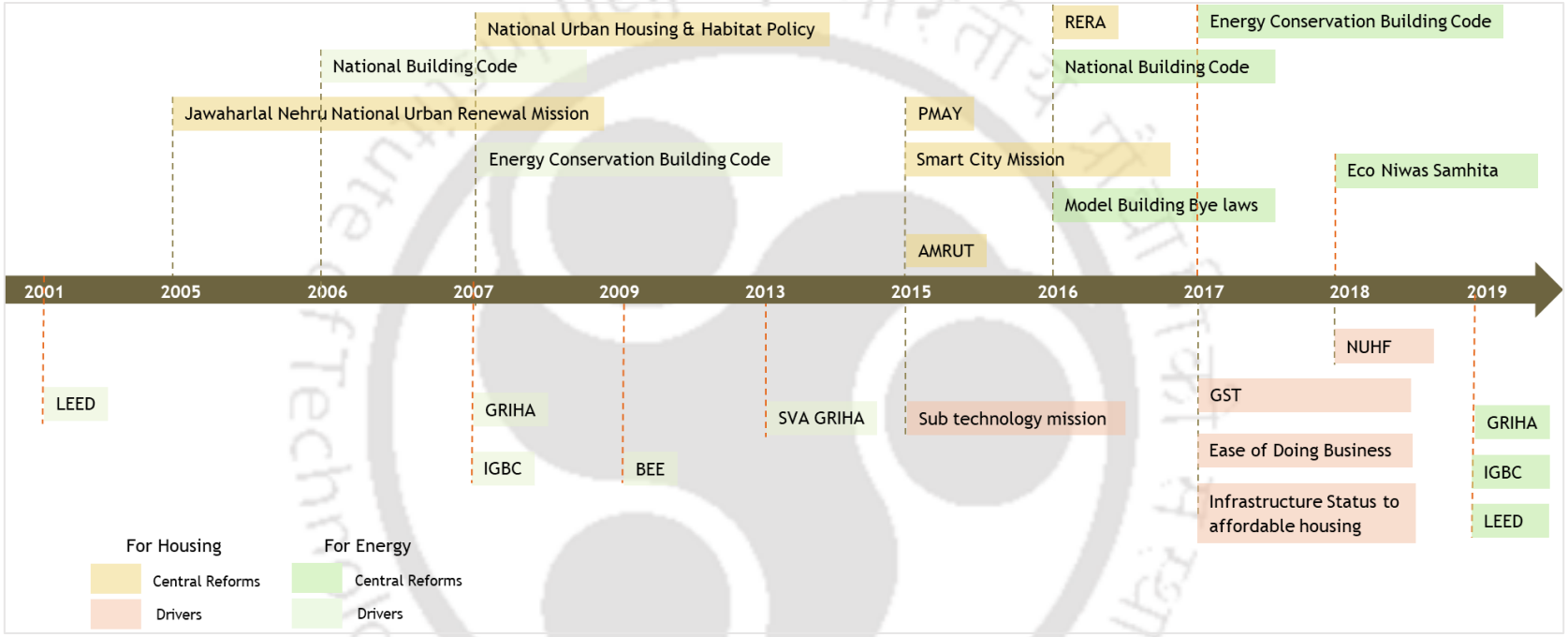

Figure 2.5 Policy Landscape For Housing And Energy

The National Building Code of India (N.B.C.), a comprehensive building code launched in 2005 and revised in 2016, is a national instrument providing guidelines for regulating building construction activities across the country (BIS, 2016). The code's provisions are intended to serve as a model for all central, state, city levels, and other construction agencies nationwide. In part 11, 'Approach to sustainability' has provided guidelines for making buildings and built environment energy-efficient and environmentally compatible which describes several measures for low energy building design and construction including (1) site, form and design where the emphasis is on-site design and development; (2) External Development and Landscape, landscape planning and design, rainwater harvesting and irrigation practices (3) Envelope Optimization focusing on energy-efficient building envelope and its methods, thermal performance and renewable energy integration, (4) Materials underlining the sustainable alternatives for construction and other efficient building material,(5) Building Services Optimization which discusses about ventilation, passive heating and cooling strategies, HVAC , Lighting : daylighting and artificial lights , renewable energy; (6) Construction Practices and (7) Commissioning, Operation, Maintenance and Building Performance Tracking (BIS, 2016).

Model Building Bye-Laws are legal guidelines developed by TCPO, which regulate building design and construction characteristics to achieve orderly development of an area and are mandatory (MoUD & GoI, 2017). It discusses environmental concerns in Chapter 10, incorporating green structures and sustainability provisions, rainwater harvesting, solar rooftop P.V. norms, and sustainable building materials. It also mentions green building rating systems. Additional chapter-13 includes providing an online building plan approval process and introducing integration into the "single window" process. It also discusses the Energy Conservation Building Code requirements from the Bureau of Energy Efficiency, Ministry of Power. The Minister of Power, New, and Renewable Energy created and launched the Eco Niwas Samhita, Part – I Building Envelope (Energy Conservation Building Code for Residential Sector) in 2018. It was designed to establish minimum building envelope performance criteria for limiting heat gains (in cooling-dominated climates), limiting heat loss (in heating-dominated environments), and providing enough natural ventilation and daylighting. The regulation applies to all residential development projects with a plot area of 500 m^2 (BEE, 2018). The guideline seeks to promote the

design and construction of dwellings, including flats and townships, to provide the residents with the benefits of energy efficiency. These have been integral to central and state policies and apply to almost all types of buildings. The guidelines/codes mentioned below highlight the importance of energy efficiency in facilities directly/indirectly dealing with energy and their role in respective areas (BEE, 2018).

Green rating methods for buildings assess and evaluate a building's environmental performance. India presently has green grading systems for buildings listed below. The Ministry of New & Renewable Energy (MNRE), the Government of India, and TERI have all recognized the Green Grading for Integrated Habitat Assessment (GRIHA) is India's national rating system for any finished development. It is a tool for measuring and rating the environmental performance of a building. The IGBC Rating System is a program that is entirely voluntary and based on consensus. This grading system would aid in creating factories that are energy-efficient, water-efficient, healthier, more productive, and ecologically friendly and is mentioned in detail in Table 2.2 (GRIHA, 2019; IGBC, 2019).

To increase green construction coverage in the country's residential sector, the CII Indian Green Building Council and the Confederation of Real Estate Developers Associations of India (CREDAI) have signed a memorandum of understanding (MoU) to advance the country's Green building movement (CREDAI, 2019). The Confederation of Indian Industrial (CII) aims to develop and preserve a climate favorable to business growth in India, collaborating with industry and government through advising and consultative procedures. CII is a non-government, non-profit, industry-led, and industry-managed organization playing a proactive role in India's development process. CREDAI is the nodal body in charge of the most critical infrastructure engine, covering all sorts of works. The collaboration of these two reputable organizations will assure quick progress toward sustainable and green buildings, neighborhoods, cities, and, eventually, a green country (CII, 2022). These industry initiatives are further mentioned in Table 2.3.

Table 2.2 Initiatives Under The Energy Sector

Initiatives	Information	Remarks
IGBC	The Confederation of Indian Industry (CII)'s Green Building Council (IGBC). The council provides various services, including developing a new green building rating program and certification services.	IGBC Green Building Rating Systems include green new/existing buildings, green residential societies, and homes.
GRIHA	GRIHA is a three-tiered green building design evaluation system for grading structures. The GRIHA grading system is comprised of 34 criteria divided into four sections: (1) site selection and site design, (2) conservation and efficient resource usage, (3) building operation and maintenance, and (4) innovation.	GRIHA for Affordable Housing: All the upcoming projects that have approval/sanction letter issued by government agencies confirming that the project is being developed as per Pradhan Mantri Awas Yojana (PMAY) are eligible for GRIHA AH rating.
BEE	BEE created its building grading system based on a 1 to 5-star scale. The Energy Performance Index was created by B.E.E. (EPI). The unit of Kilowatt hours per square meter per year is used to rate the building, with an emphasis on air-conditioned and non-air-conditioned office buildings	B.E.E. standards and labeling require displaying energy performance labels on high-energy end-use equipment and appliances and establishing minimum energy performance criteria.
SVAGRIHA	SVAGRIHA was created as an extension of GRIHA and was designed mainly for projects with a built-up area of less than 2500 sq. m. SVAGRIHA may assist in developing and evaluating individual houses, small offices, schools, hotels, and commercial structures, among other things. The rating has only 14 factors, and the U.I. has simplified calculators.	

Table 2.3. Industry Incentives For Green Building Construction

Initiatives	Information	Remarks
CREDAI	The Confederation of Real Estate Developers' Associations of India (CREDAI) was founded in 1999 with the Mission of advocating for housing and habitat suppliers. Its membership has increased since then, and it now boasts over 20,000 members dispersed throughout 21 states and 220 local chapters.	IGBC and CREDAI shall coordinate with the Government- both Central and State- to offer Policy incentives to IGBC-rated projects. It will also work for faster environmental clearance for IGBC projects and other Government initiatives.
EDGE (Excellence in Design for Greater Efficiencies)	The Confederation of Real Estate Developers' Associations of India (CREDAI) has collaborated with IFC (International Finance Corporation), a member of the World Bank Group, to promote green buildings in India through EDGE certification. EDGE is set to accelerate mainstreaming green buildings nationwide quickly, easily, and cost-effectively.	EDGE focuses on building energy and water efficiency. It enables builders and homeowners to select environmentally friendly technological solutions while tracking expenses and expected savings.
CII	CII aims to provide world-class advice in green buildings, energy efficiency, water management, environmental management, renewable energy, green company incubation, and climate change activities.	Since 2001, the Indian Green Construction Council (IGBC), a division of CII, has led the country's green building movement with the assistance of stakeholders.
Green Co Rating System	GreenCo Rating is a comprehensive framework that evaluates enterprises on	The Green Company Rating System advocates a performance-

	the environmental friendliness of their operations using a life cycle approach. It is the "first of its type in the World." GreenCo rating implementation offers organizations leadership and advice on making their goods, services, and processes more environmentally friendly.	based approach. The grading method assesses characteristics against ten criteria. Certification is available for both manufacturing and service sector establishments. The rating is applied at the unit or facility level.

2.3.Introduction To Green Building Rating Systems

2.3.1. Indian Rating Systems

This section draws attention to building rating systems. Green building rating systems assess and measure a structure's environmental performance. Buildings in India are currently rated using the green grading systems listed below. The Ministry of New & Renewable Energy (MNRE), GoI, and TERI have recognized the Green Grading for Integrated Habitat Assessment (GRIHA) as India's national rating system for any finished development. It's a tool for assessing and rating a building's environmental performance (GRIHA, 2019). The IGBC Rating System is a consensus-based, voluntary initiative. This rating system would facilitate energy-efficient, water-efficient, healthy, more productive, and environmentally friendly factories (IGBC, 2019). The Leadership in Energy and Environmental Design (LEED-INDIA) Green Building Rating System is a widely accepted standard for designing, constructing, and operating high-performance green buildings in India and worldwide (USGBC, 2020).

BEE has evolved with the residential building energy efficiency label launched by MNRE in 2019. The plan's primary goal is to create a transparent tool for house energy efficiency and gradually form a practical model to consider when determining house prices. The labeling scheme aims to turn the energy efficiency of houses into a comparison tool when choosing future house prices. It also seeks to provide a benchmark for comparing homes with energy efficiency standards to create consumer-centric market transformation solutions for energy efficiency in the housing sector (BEE, 2019).

The Ministry of New and Renewable Energy (MNRE), Government of India, and TERI developed in 2005. It recognized the Green Rating for Integrated Habitat Assessment (GRIHA) as India's national rating system in 2007 for any finished structure (GRIHA, 2019). It's a tool for assessing and rating a building's environmental performance. GRIHA v.2019 certifies all new construction projects with a built-up area of more than 2500 m2 (excluding parking, basement area, and typical facilities). The projected outcomes determine a structure's worth on its whole lifespan (GRIHA, 2019). It is a three-tiered green building design evaluation method for grading facilities. The 34 criteria of the GRIHA grading system are divided into four sections: site selection and planning, resource conservation and efficient use, building operation and maintenance, and innovation. This version has considered user input, improved ease of implementation and acceptance, and other factors not considered in earlier editions (GRIHA, 2019).

GRIHA's goals align with the realization of SDGs, especially those that affect the scope of sustainable building development. GRIHA was developed to evaluate the environmental performance of all livable spaces, which can be air-conditioned, non-air-conditioned and hybrid, in terms of energy and water consumption, resource use and waste management throughout their life cycle. It can be applied to existing buildings and new buildings. The rating system considers regional climate conditions and provides local solutions considering location constraints. In addition, GRIHA ratings attach great importance to passive planning strategies to lay the foundation for the construction process that contributes to developing economic and resource-saving projects. GRIHA integrates various relevant Indian construction, energy, water, materials and waste management codes to act as a tool to promote the implementation of these codes. GRIHA v.2019 is divided into ten environmental parts, subdivided into 29 standards, covering all the necessary parameters to consider when creating a "green building". The additional part of "innovation" is the rating system, which rewards project teams that make more effort to achieve environmental and social sustainability (GRIHA, 2019).

SVAGRIHA is designed as an extension of GRIHA and is specially developed for projects with a floor area of less than 2500 square meters. SVAGRIHA can help plan and evaluate individual apartments, small offices, schools, motels, commercial buildings, etc. The evaluation includes only

14 standards, and the interface consists of a simplified calculator (GRIHA, 2019). The standard weight of GRIHA is shown in Figure 2.6.

Envisioned in 2007, the Confederation of Indian Industry (CII), with the Indian Green Building Council (IGBC), created an exclusive rating system focusing on the design of green homes and launched it in 2009. The council provides various services, including creating a new green building rating system and certification services (IGBC, 2019). The rating system was designed to address national concerns and stimulate dwellings, including traditional Indian architectural techniques and current technological advancements. Green new/existing buildings, green residential societies, and green residences are included in the IGBC Green Building Rating Systems. It's a voluntary, consensus-based approach that helps buildings become more efficient and environmentally friendly (IGBC, 2019). The qualification program uses recognized national standards; where local or national standards are not obtainable, appropriate global measures have been considered. The Green Home Rating System addresses critical national priorities, including water conservation, household waste management, energy efficiency, reducing fossil fuel consumption, reducing dependence on the use of new materials, and the health and well-being of residents (IGBC, 2019).

The appraisal system was created considering the Indian climate and housing construction methods and was designed to evaluate new and significant renovations of residential sector buildings. Detailed guidelines for each mandatory requirement and credit allow the design and construction of green spaces of all types. Different levels of certification are given based on the number of credits received. Each house must meet all obligatory and non-negotiable requirements.

Green Homes, developed by the Indian Green Building Council (IGBC), is the first rating system designed specifically for the residential sector in India (IGBC, 2019). It is founded on well-established energy and environmental principles and balances well-established procedures and new ideas. The system is intended to be both comprehensive and straightforward to use. Site Selection and Planning, Water Conservation, Energy Efficiency, Materials & Resources, Indoor Environmental Quality, and Innovation & Design Process are all covered by the IGBC Green Homes rating system. IGBC criteria weightage is shown in Figure 2.7. The International Green

Building Council (IGBC) has also created a green building rating system for Affordable Housing and Green Residents (IGBC, 2019).

LEED is a globally recognized external green building certification program for designing, constructing, and operating high-performance green buildings (USGBC, 2020). It started in 1998 and is an independent initiative of the U.S. Green Building Council to evaluate and rate various buildings. LEED (Leadership in Energy and Environmental Design) is the most widely used environmental building rating system globally. It is the Indian Green Business Center (IGBC) under the Confederation of Indian Industry (CII) that has received the LEED rating from the United States Green Building Council (USGBC) (USGBC, 2020).

The certification applies to all building types and construction phases, including new buildings, interior buildings, operations and maintenance, and core and shell buildings. It also issues some country-specific requirements. The latest version of LEED, LEED v4.1, improves building standards, including energy efficiency, water conservation, site selection, material selection, daylight, and waste reduction (USGBC, 2020). It proposes a new housing project approach that draws the most relevant language from BD+C and all housing-related rating systems and combines it with the priorities of the housing market. LEED has developed a specific version adaptable for India, considering the country-specific context. The LEED v4.1 multi-family residential rating system has four main goals: ensuring leadership, improving accessibility, measuring performance, and expanding the market (USGBC, 2020). The weight of the LEED standard is shown in Figure 2.8.

2.3.2. International Rating Systems

The subsequent international building grading systems are selected because they are widely acknowledged as the most known and trusted tools worldwide. Furthermore, the Indian green building rating system symbolizes the research case study's national rating system. These methods were examined to determine which elements and indicators impacted the building's performance most. A review of the obtainability and incorporation of socio-cultural indicators for sustainable development is also presented, along with helpful suggestions for improvement. Only residential strategies were evaluated in these rating systems' first and most recent editions. The study

concentrates on well-known and well-respected methodologies that employ a qualitative method to examine both human and natural systems in the urban environment.

The Building Research Establishment created the Building Research Establishment Environmental Assessment Method (BREEAM) to establish best practices in sustainable design, construction, and management (BRE, 2017).BREEAM employs a weighing and assessment methodology that includes comparing indicators to set standards and levels of performance and awarding credits in 10 categories. Each area has several criteria, including pre-weighted points that might be cumulative or based on performance under EIA guidelines established by the UK government and the European Union (EIA, 2009). The evaluation scale is passed, good, very good, excellent, and outstanding. These credits are combined to generate a single overall score (BRE, 2017).

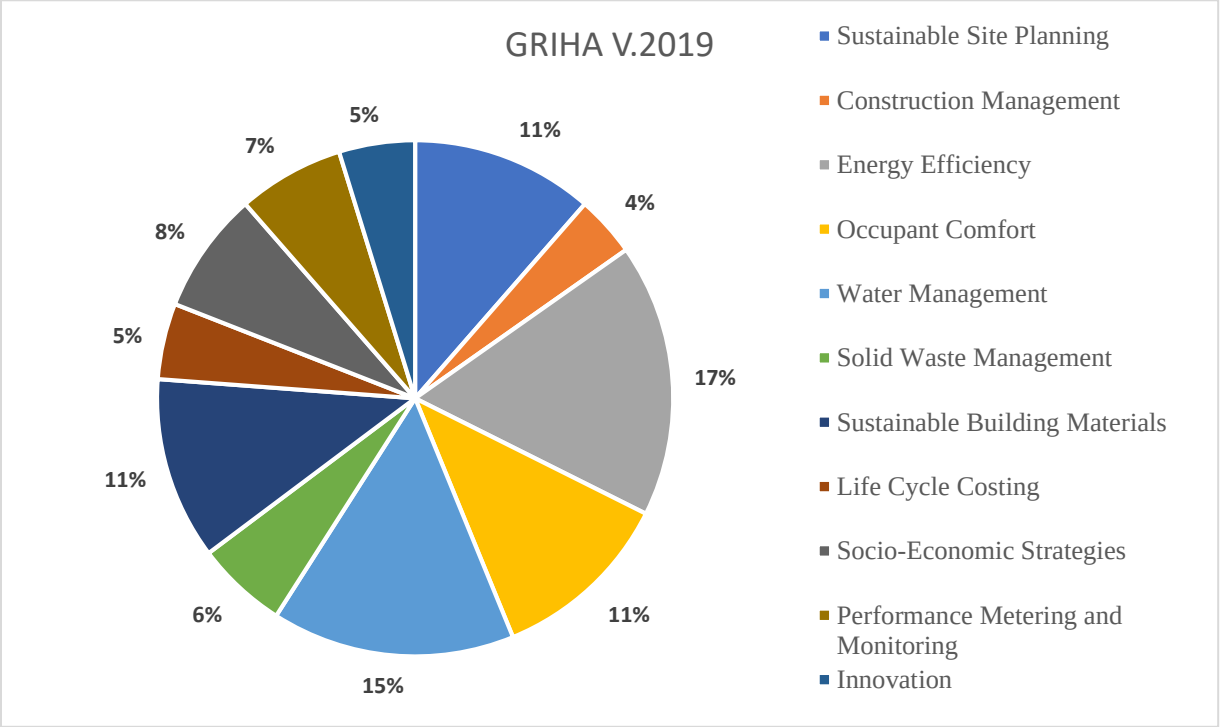

Figure 2.6. Section-Wise Weightage Of GRIHA Criteria.

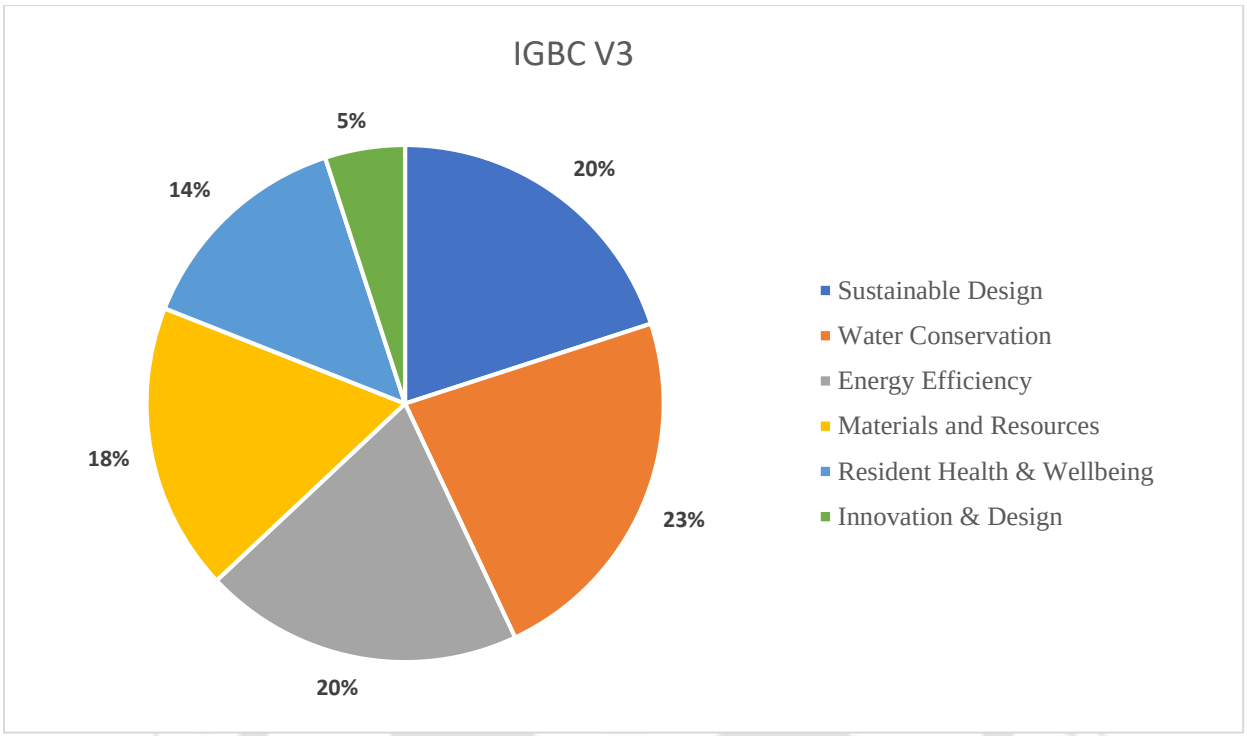

Figure 2.7 Section-Wise Weightage Of IGBC Criteria.

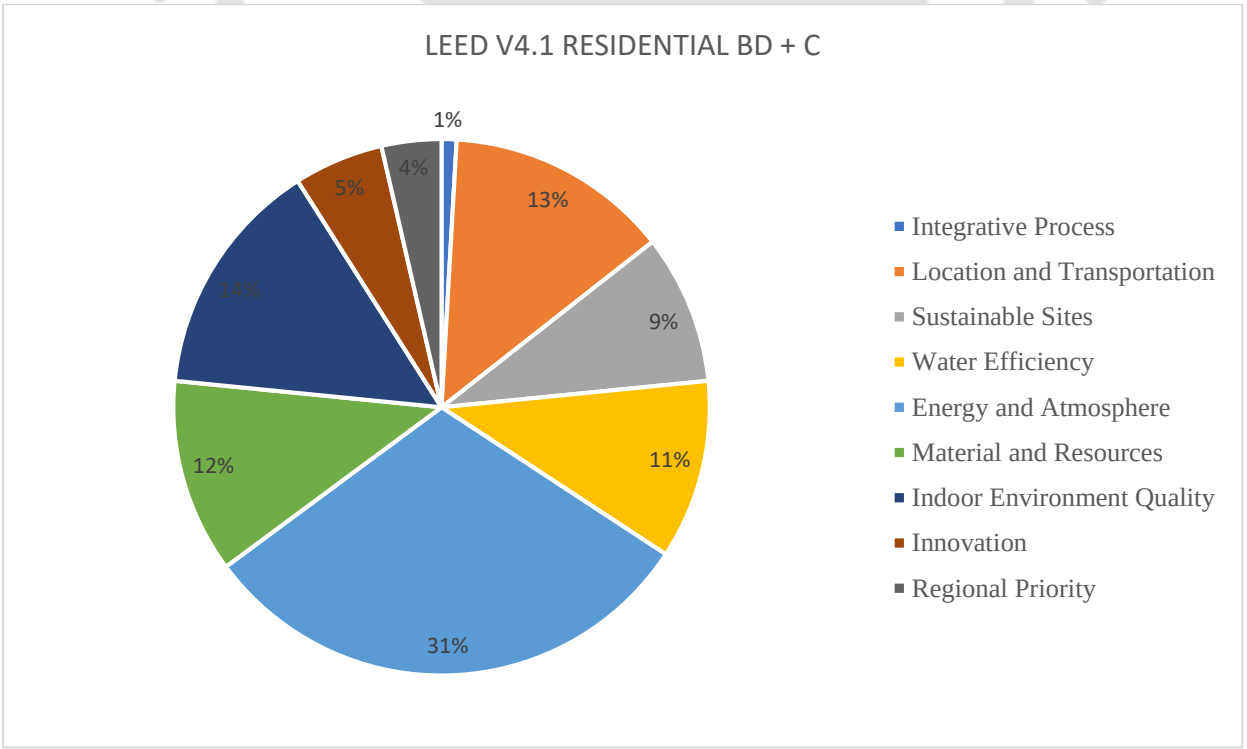

Figure 2.8. Section-Wise Weightage Of LEED V4.1 Criteria.

The Japanese Sustainable Building Consortium created the Comprehensive Assessment System for Built Environment Efficiency. This approach may be used at different phases of a building's life cycle (design, new construction, existing buildings, and renovation projects) (IBEC, 2007). The CASBEE rating system for construction projects is distinct from other rating systems. It is accomplished via the use of a metric known as Building Environmental Efficiency (BEE), which is calculated as the ratio of two metrics: built environmental quality (Q) and built environmental load (BEL). LR evaluates how the daily amenities for building occupants have improved within the perimeter of the virtual enclosed space. The negative aspects of environmental consequences that go beyond the immediate region are calculated by LR (Bernardi et al., 2017). The three subcategories comprising the Q and LR scores, which range from 0 to 100, are determined using an assessment form. Each category (quality of service, on-site outdoor environment, internal environment, resources & material, off-site environment, and energy) has a corresponding weight (IBEC, 2007).Each category is given a score between one and five, with five representing the highest rating (the highest point of accomplishment). The score and rating can be shown in various ways, giving users further options in how to use the data.

IISBE manages SB Tool, a software application of the Sustainable Building Challenge (SBC) evaluation technique, which has been developed as the Green Building Challenge procedure since 1996 by a consortium of 14 nations. SB Tool is unusual because it was built from the ground up to represent other areas and nations' goals, technology, construction traditions, and cultural values (iiSBE, 2007). The SB Tool may be used for projects ranging from a single structure to a whole city and has been translated into various languages. Its approach allows for quickly adding local criteria and language and adjusting indicator weightings based on priorities and specific conditions (iiSBE, 2007). Site selection, project planning and development, environmental loadings, energy and resource consumption, interior environmental quality, building system functionality, and controllability, long-term effectiveness, and social and economic indicators are the seven factors that the tool examines. Individuals, society, and nature are pre-weighted in SB Tool, with values ranging from 1 to 5 (iiSBE, 2007).

2.3.3. Review Of Indian Rating Systems On Sustainability Indicators

In this chapter, an in-depth study of the parameters of these assessment methods is directed at the social, economic, and environmental factors. All the required information is collected using explanatory documents and their portals. The study used the latest versions of these systems: GRIHA v2019, IGBC v3, and LEED v4.1 for BD+C: New Construction and Major Renovation. Each criterion from the rating system is mapped to target three pillars of sustainability. Table 2.4 showcases an overview of all rating systems gauging them on feasibility. Another set of three tables here displays each system's information, point division and score allotment of each criterion, and analysis with three pillars. Table 2.5, 2.6, and 2.7 below shows the data on the study of GRIHA, IGBC, and LEED with pillars of sustainability and similar for other rating systems.

Table 2.4 Overview Of Selected Green Building Rating Systems

Category	GRIHA (GRIHA v.2019)	IGBC (IGBC Green Homes Version 3)	LEED (LEED v4.1 Adopted for India)
Launch year	2007	2007	2001
Latest Version	2019	2019	2019
Scope	All new construction projects (Multi-dwelling unit) with built-up areas of more than 2500 m^2	Individual and Multi-dwelling residential units	Multifamily Midrise or BD+C residential project
Score	105 - possible points system	100 - point system	110 - possible points system
Rating	Four Star Rating system	Four Level certification (Certified/ Silver/ Gold/ Platinum)	Four Level certification (Certified/ Silver/ Gold/ Platinum)
Validity/ Renewal	Five years	Three years	Three years
Fees	Calculated as per the built-up area	Calculated as per the built-up area and project types	The certification fee is based on your project's rating system and size

Table 2.5 Analysis Of GRIHA V.2019 With Pillars Of Sustainability.

S.no	Category	Point	Division	Criteria	Environment	Social	Economic
1	Sustainable Site Planning	12	5	Green Infrastructure	Y		
			5	Low Impact Design	Y		
			2	Design to Mitigate UHIE	Y		
2	Construction Management	4	1	Air and Soil Pollution Control	Y		
			1	Top Soil Preservation	Y		
			2	Construction Management Practices			Y
3	Energy Efficiency	18	12	Energy Optimization	Y		Y
			5	Renewable Energy Utilization	Y		Y
			1	Low ODP and GWP Materials	Y		
4	Occupant Comfort	12	4	Visual Comfort	Y	Y	
			2	Thermal and Acoustic Comfort	Y	Y	
			6	Maintaining Good IAQ	Y		
5	Water Management	16	4	Water Demand Reduction	Y		Y

			2	Waste water Treatment	Y		
			5	Rainwater Management	Y		Y
			5	Water Quality and Self-Sufficiency	Y	Y	
6	Solid Waste Management	6	4	Waste Management-Post Occupancy	Y	Y	
			2	Organic Waste Treatment On-Site	Y		
7	Sustainable Building Materials	12	5	Utilization of Alternative Materials in Building	Y		Y
			5	Reduction in GWP through Life Cycle Assessment	Y		Y
			2	Alternative Materials for External Site Development	Y		Y
8	Life Cycle Costing	5	5	Life Cycle Cost Analysis	Y		Y
9		8	1	Safety and Sanitation for	Y	Y	

	Socio-Economic Strategies			Construction Workers			
			2	Universal Accessibility		Y	
			2	Dedicated Facilities for Service Staff		Y	
			3	Positive Social Impact		Y	
10	Performance Metering and Monitoring	7	0	Commissioning for Final Rating			
			7	Smart Metering and Monitoring	Y		Y
			0	Operation and Maintenance Protocol			
11	Innovation	5	5	Innovation			

Table 2.6 Analysis Of IGBC V3 With Pillars Of Sustainability.

S.no	Category	Point	Division	Criteria	Environment	Social	Economic
1	Sustainable Design	20	*	Local Building Regulations		Y	
			*	Soil Erosion Control	Y		
			4	Natural Topography & Vegetation	Y		
			4	Heat Island Effect, Roof & Non-roof	Y		
			2	Passive Architecture	Y		
			2	Universal Design			
			4	Green Parking Facility	Y		
			2	Access to Amenities		Y	
			1	Basic Facilities for Construction Workforce		Y	
			1	Green Education & Awareness		Y	
2	Water Conservation	23	*	Water Efficient Plumbing Fixtures	Y		Y
			*	Rainwater Harvesting	Y		Y
			6	Water Efficient Plumbing Fixtures	Y		Y
			3	Landscape Design	Y		

			2	Management of Irrigation System	Y		Y
			4	Recycle & Reuse of Wastewater	Y		Y
			1	Water Quality	Y		
			4	Enhanced Rainwater Harvesting	Y		
			3	Water Metering	Y		Y
3	Energy Efficiency	20	*	HCFC Free Equipment	Y		
			*	Minimum Energy Performance	Y		Y
			10	Enhanced Energy Performance	Y		Y
			3	Alternate Water Heating system	Y		
			4	On-site Renewable Energy - Common area Lighting	Y	Y	Y
			1	Energy efficiency in common area equipment	Y	Y	Y
			2	Integrated Energy Monitoring System	Y		Y
4	Materials and Resources	18	*	Separation of Household Waste	Y		
			1	Green Procurement Policy	Y		
			1	Optimization on Structural Design	Y		

			5	Certified Green Products	Y		
			2	Local Materials	Y		Y
			2	Eco-friendly wood-based materials	Y		Y
			2	Alternative Construction Material	Y		
			2	Handling of Construction & Demolition Waste	Y		
			3	Organic Waste Treatment Post Occupancy	Y		
5	Resident's Health & Wellbeing	14	*	Minimum Daylighting, 50%	Y	Y	
			*	Ventilation Design	Y		
			*	No Smoking Policy	Y		
			2	Enhanced Daylighting	Y	Y	
			2	Enhanced Ventilation Design	Y		
			4	Cross Ventilation		Y	
			2	Connectivity to Exteriors		Y	
			2	Low VOC Materials, Paints & Adhesives	Y		Y
			2	Facility for Physical Well-being		Y	
6		5	2	Innovation			

	Innovation & Design		2	Exemplary Performance			
			1	IGBC Accredited Professional			

Table 2.7 Analysis Of LEED V4.1 BD + C For Residential Buildings (Adapted For India) With Pillars Of Sustainability.

S.no	Category	Point	Division	Criteria	Environment	Social	Economic
1	Integrative process	1	1	Integrative Process			
2	Location and Transportation	15	n/a	LEED for Neighbour-hood Development		Y	
			15	Location			
			2	Sensitive Land Protection	Y		
			1	High-Priority Site			
			5	Surrounding Density and Diverse Uses		Y	
			3	Access to Quality Transit		Y	
			1	Bicycle Facilities	Y		Y
			1	Reduced Parking Footprint	Y		

			2	Electric Vehicles	Y		Y
3	Sustainable cities	10	*	Construction Activity Pollution Prevention	Y		
			1	Site Assessment			
			1	Protect or Restore Habitat	Y		
			1	Open Space			
			3	Rainwater Management	Y		Y
			2	Heat Island Reduction	Y		
			1	Light Pollution Reduction	Y		
			n/a	Tenant Design and Construction Guidelines		Y	
4	Water efficiency	12	*	Water Use Reduction	Y		Y
			*	Building-Level Water Metering	Y		Y
			10	Water Use Reduction			
			2	Water Metering			

5	Energy and atmosphere	34	*	Fundamental Systems Testing and Verification	Y		
			*	Minimum Energy Performance	Y		Y
			*	Energy Metering	Y		Y
			*	Fundamental Refrigerant Management			
			6	Enhanced Commissioning			
			18	Optimize Energy Performance	Y		Y
			1	Whole Building Energy Monitoring and Reporting	Y		
			2	Grid Harmonization	Y		
			5	Renewable Energy	Y		Y
			1	Enhanced Refrigerant Management			

			1	Efficient Hot Water Distribution Systems	Y		Y
6	Materials and resources	13	*	Storage and Collection of Recyclables	Y		
			*	Construction and Demolition Waste Management Planning	Y		
			5	Building Life-Cycle Impact Reduction	Y		
			6	Environmentally Preferable Products Construction and Demolition Waste	Y		Y
			2	Management	Y		Y
7	Indoor environmental quality	16	*	Minimum Indoor Air Quality Performance	Y	Y	
			*	Combustion Venting	Y		
			*	Garage Pollutant Protection	Y		

			*	Radon-Resistant Construction	Y		
			*	Interior Moisture Management	Y	Y	
			*	Environmental Tobacco Smoke Control	Y		
			*	Compartmentalization		Y	
			1	Enhanced Compartmentalization		Y	
			1	No Environmental Tobacco Smoke			
			4	Enhanced Indoor Air Quality Strategies	Y	Y	
			4	Low-Emitting Materials	Y		
			2	Indoor Air Quality Assessment	Y		
			1	Thermal Comfort	Y	Y	
			1	Daylight and Quality Views	Y	Y	

			2	Acoustic Performance	Y	Y	
8	Innovation	6	5	Innovation			
			1	LEED Accredited Professional			
9	Regional priority	4	4	Regional Priority		Y	Y

(* denotes mandatory prerequisite criteria)

The above-shown analysis represents the three green building rating systems adopted for India and their analysis concerning pillars of sustainability. Below, Table 2.8 depicts the aspects inferred from the above classification into environmental, social, and economic factors.

Table 2.8 Analysis Of Primary Green Building Rating Systems.

Category	Environmental	Social	Economical	Remarks
GRIHA	GRIHA's criteria are aligned with SDG and hence have a significant part focused on the environmental aspect.	GRIHA contains a dedicated section for assessing socio-economic strategies and occupant comfort.	The parameters are focused on management practices and alternation in energy and water usage. For building materials, if they could be locally procured.	GRIHA also focuses on life cycle cost analysis and water performance index
IGBC	The goal of IGBC is the effective use of all resources in terms of energy efficiency.	IGBC focuses on residents and well-being in terms of interior	IGBC suggests the use of alternate construction materials and	IGBC Green Homes is the first rating system developed in India solely for the residential sector.

		environment control and not parameters like human health	water and checks resource management and operating energy costs from the first day during the entire life cycle of the building	The system is built on recognized energy and environmental principles, balancing well-known practices and developing concepts.
LEED	LEED intensely focuses on material selection, resident comfort, air quality, and health.	LEED mentions social aspects like open space access, transportation aspects like bicycle facilities, and quality views. The system ensures that the building is not isolated from social parts of its community but prioritizes access and inclusion for all.	LEED focuses on environment-friendly products and resource management.	LEED rating system has maintained equilibrium between all pillars. It has a dedicated section for regional priority which addresses geographically specific environmental, social equity, and public health urgencies.

2.3.4. Review Of Rating Systems On Sustainability Assessment

Since 1990, standards and rating systems have been extensively developed to assess the environmental performance of green buildings. Chapter 1, section 1.3.4, elaborates on different rating systems from developed and developing countries. Below Table 2.9 displays a brief about all these systems. These systems have been analyzed again in detail based on their context, guidelines, weightage of indicators, socio-cultural indicators, terminologies, stakeholder participation, and user involvement.

Table 2.9 Overview Of The Rating Systems For Sustainability Assessment.

INTERNATIONAL GREEN BUILDING RATING SYSTEMS			
Name	**BREEAM**	**CASBEE**	**SB-TOOL**
Developed by	Build Research Establishment (BRE)	Institute for Building Environment and Japan Sustainable Building Consortium (JSBC) and Energy Conservation (IBEC)	International Initiative for Sustainable Built Environment (iiSBE)
Origin	United Kingdom	Japan	International
Method of evaluation	Checklist on excel	Technical Guideline Excel sheet and software	Software and Excel tool
Stages of evaluation	Building and neighborhood scale. Applicable for new, refurbished, and existing buildings	Building, neighborhood, district, and city level. Applicable for new and existing buildings	New, refurbished, and existing buildings
Assessment method	Pre-weighted categories	BEE ranking chart built on ratio ranking	Logarithm-based weighting system

Categories and Weightage	Governance-8, Resources and energy-47, Transport and movement-158, Land Use and ecology-18, Social and economic well-being-31	The tool has 80 sub-criteria, divided into two main clusters: Environmental Quality and Environmental Loadings, shown as Q and L. The final score is calculated as BEE= EQ/ EL	Site Selection and project planning & development-8, Social & economic aspects-5, Energy and resource consumption-21, Cultural & perceptual aspects-5, Indoor environment quality-21, Environmental loadings-25, Service quality-15
Performance Rating	Outstanding = >85% Excellent = 70-84% Very good = 55 - 69% Good = 40 - 54% Pass = 25 - 39%	Poor: BEE < 0.5 Fairy Poor: BEE = 0.5–1.0 Good: BEE = 1–1.5 Very good: BEE = 1.5–3; or BEE ≥3 and Q < 5 Excellent: BEE ≥3 and Q ≤ 5	-1 Poor 0 1 3 5 Excellent
INDIAN GREEN BUILDING RATING SYSTEMS			
Name	**LEED**	**GRIHA**	**IGBC**
Developed under	United States Green Building Council (USGBC)	Ministry of New and Renewable Energy (MNRE)	The Energy and Resources Institute (TERI)
Origin	USA	India	India
Method of evaluation	PDF Guideline book and Excel checklist	PDF Guideline book and Excel checklist	PDF Guideline book and Excel checklist
Stages of evaluation	Multifamily Midrise or BD+C residential project	All new construction projects (Multi-dwelling units) with a built-up area >2500 m^2	Individual and Multi-dwelling residential units

Assessment method	Pre-weighted categories	Pre-weighted categories	Pre-weighted categories
Categories and Weightage	Integrative process-1, Location and transportation-15, Sustainable cities-10, Water efficiency-12, Materials and resources-13, Energy and atmosphere-34, Indoor environmental quality-16, Innovation-6, Regional priority-4	Sustainable Site Planning-12, Construction Management-4, Energy Efficiency-18, Occupant Comfort-12, Water Management-16, Solid Waste Management-6, Sustainable Building Materials-12, Life Cycle Costing-5, Socio-Economic Strategies-8, Performance Metering, and Monitoring-7, Innovation-5	Sustainable Design-20, Water Conservation - 23, Energy Efficiency-20, Materials and Resources-18, Resident Health & Wellbeing-14, Innovation & Design-5
Performance Rating	Four Level certification (Certified/ Silver/ Gold/ Platinum)	25-40 * 41-55 ** 56-70 *** 71-85 **** 86 or more *****	Four Level certification (Certified/ Silver/ Gold/ Platinum)

- Weightage of criteria

The current green building rating system greatly influences environmental aspects like energy, resources, site context, and similar categories with multiple terms in different rating systems. The intangible factors of social and cultural indicators are not considered while building these systems. The most commonly targeted sectors amongst all assessment methods are environmental, the most dominated, water management, energy, material, and resources. Over fifty percent of the criteria in these methods depict environmental aspects.

- Existence of socio-cultural indicators

The assessment methods studied here have not taken social and cultural indicators in their system to a considerable extent. The health and well-being aspect of the user is also restricted. These aspects' intangible nature limits the applicability and hence is isolated. The tools analyzed in the study do not consider a related approach towards adopting social and cultural indicators w.r.t. to user needs and sustainable development. Non-environmental aspects considered in the methods mainly focus on socio-economic concerns like transportation, access to amenities, other services, and safety. A construction project might receive a sustainability certificate under existing assessment techniques without fully considering sustainable development features. Furthermore, when cultural and social sustainability are recognized as pillars of sustainable development, none of the developed methods has made cultural indicators an obligatory criterion. More focus should be placed on tying environmental practices to inhabitants' social and cultural well-being and requirements since this is critical for the housing project's long-term viability.

- Involvement of users and residents

Users and occupants can be involved when ideating the indicators for assessment and determining the criteria to be considered. Citizen and community initiatives, according to James (2015), give innovative and transferable solutions to intractable social and environmental problems. Users can also take part in the weighting of several factors. Building assessment can be improvised using a consensus-based weighting system for distinct categories. Architects and developers can utilize user feedback by considering their input and determining whether suggested changes are necessary to match economic development and social demands.

- Stakeholder contribution

The analyzed tools only consider taking an expert opinion (professionals, consultants, academicians) while selecting criteria and incorporating weightage. User involvement is not considered in tools w.r.t. weightage and feedback process. The user's interest in the tool's development is not considered. It can be observed that the user's involvement cannot be seen

during the assessment period at any developing stage: pre-construction, developing phase, or post-occupancy.

- Adaption to the local context

The current systems were developed to provide a generic approach to sustainability assessment. These systems do not consider local or regional context while adopting the method. Few focus on the local materials and technologies, but a more prominent strategy is still needed to encourage the utilization of locally accepted methods. Innovation is one standard indicator seen across all tools, which can be ideated to incline toward local innovation strategies.

2.3.5. Discussions

India has varied social and cultural norms and very distinctive climate regions. To address issues needs a regional strategy or a customized approach. Here, local materials and solutions are more resilient. More social and cultural aspects appropriate for Indian typology must be added. This study of rating systems and other relevant literature has suggested a few possible additions to the existing rating system criteria, showcasing them in Table 2.10 below. These indicators are proposed after reviewing India's existing green building rating system. These possible lists of indicators below might be implemented as add-on features to the existing rating systems. These pointers are identified from the current database, like national policies and guidelines and reports from national and international organizations. The indicators are shortlisted based on: 1. Their importance in a particular category; 2. They have been mentioned as a strategy at other national guidelines; 3. The researcher has interpreted this indicator based on their mentions of multiple scenarios. The additional indicators can be considered when improvising the existing system or developing a new framework.

Table 2.10 List Of Additional Indicators For More Sustainable Typology.

Indicator	**Aspect**		
Social	Resident wellbeing	Proximity to services and transportation	Privacy and safety measures
	Disability needs	Consciousness towards sustainability	Senior citizen and childcare
Economic	Affordability and durability	Policy and regulations	Optimization of energy and operations
	Construction management practices	Locally sourced material and technology	Resource utilization
Environmental	Recyclable materials	Use of locally available materials and technology	Waste management
	Green areas and vegetation	Hazard prevention	Renewable energy
Cultural	The aesthetic and visual impact	Inter-regional impact	Dwelling functionality
	Cultural relevance	Values and belief	Hierarchy of spaces
User Experiences	Adaptability and usage	Satisfaction level	Awareness

Construction of green buildings, abiding by standard practices and assessments, is essential for attaining sustainability. To accomplish sustainable development, more attention should be given to three aspects: environmental, social, and economic impacts related to the pre and post-construction practices and operation of buildings. India has three effective systems for boosting environmentally sustainable practices for its rapidly increasing urban population. In this study, three green building assessment tools, namely Green Rating for Integrated Habitat Assessment (GRIHA), Indian Green Building Council (IGBC), and Leadership in Energy and Environmental Design (LEED), are reviewed in terms of how they work and their contribution towards the pillars

of sustainability. These systems have varied ways to assess the building's needs, all focusing on the building's environmental and a few economic aspects. With this analysis, one can say that there is a need to adopt more suited parameters per the regional requirement and human comfort. A place's social and cultural sustainability can be interlinked while describing the indicator due to commonality. Culture is an inherited part of Indian society; hence, it is nearly impossible to study the social aspects of a place without considering the culture. There is a need to focus more on socio-cultural indicators of the buildings and their impact on neighboring areas. This study will help analyze the current picture of green building rating methods and suggest factors that can be added to other revised versions.

The study on sustainability assessment analyzes six building assessment methods regarding their origin, criteria, processes, weighting, performance, and sustainability indicators. It can be seen that the sustainability metrics indicated in these tools have various priorities depending on context and country, particularly in developing countries. On the other hand, sustainable building grading tools are similar because they usually consist of optional criteria. The process of selecting standards and assigning weighting is frequently subjective as well. Although current sustainable building assessment methods include a mix of quantitative and qualitative indicators, they prioritize environmental and physical aspects over socio-cultural factors.

The idea and standpoints on socio-cultural components are still included in understanding the vernacular and traditional approach of the society, their needs, and context. The compatibility of the strategy implemented to achieve sustainability is not considered/ given much attention based on the regional and local context of the residents. These strategies receive little consideration furthermore when it comes to developing countries. The analysis indicates a lack of balance across various sustainability characteristics. This disparity suggests that the problem of integrated sustainability has yet to be adequately communicated within the developed framework for building assessment. The indicators directed towards environmental aspects continue to outnumber other, less physical elements. While tangible indicators are essential for accomplishing environmental sustainability goals, other indicators and their importance in achieving intra-generational and social fairness have been disregarded. The usability and utility of generalizing tools in many

contexts and regions are also recurring challenges in sustainable building assessment methodologies.

A more customizable evaluation tool is still needed to satisfy geographically particular environmental, social, or cultural goals. Experts and specialists are responsible for determining the indicators and must consider local norms and strategies to encourage community participation and development. User and resident interaction are also encouraged in identifying the indicators.

2.4.Understanding Social And Cultural Indicators

This section emphasizes understanding the social and cultural sustainability criteria indicators based on existing policies and scholarly work available. This section highlights the pointers covered over these guidelines and a few recommended by world organizations like United Nations and UNESCO. Since the Brundtland Report and Agenda 21, urban nature has grown for social, cultural, and environmental reasons. Culture comprises a natural dimension as an ensemble of real vectors of social life. This dimension must resurrect to strengthen and make culture's role in sustainable development more tangible (United Nations, 1992a)(Brundtland, 1987). Socially sustainable communities are equitable, diversified, interconnected, and democratic, promoting a high quality of life. Chiu has also focused on social sustainability and presented it in three interrelated perspectives: development-oriented, environmental, and people-oriented (RLH Chiu, 2003).

A given landscape defines social and cultural requirements as living space, including tangible aspects like aesthetics, elements, and structure such as historical relics and human habitat, and intangible such as the feeling of home, local culture, and customs. However, these social and cultural components are challenging to describe and quantify, and their integration into planning is lacking. Table 2.11 showcases information on each indicator based on a review of policies, databases, and scholarly work. The paper uses the latest versions of green building rating systems applicable for India: GRIHA v2019, IGBC v3, and LEED v4.1 for BD+C: New Construction and Major Renovation.

Table 2.11 Understanding Social and cultural indicators.

Social Indicator	Policies/ Reforms:	Cultural Indicator	Policies/ Reforms:
Special requirements for citizens	NBC 2016	**Regional priority**	LEED v4.1
Socio-economic strategies	GRIHA v.2019	**Cultural forms and local practices**	UNESCO 2010, 2015, Dessein et al. 2015
Resident Well-being	IGBC v3	**Culture diversity**	UNESCO 2010, 2015
Transportation	LEED v4.1	**Culture as a part of community development**	UNESCO 2010
Neighborhood development	LEED v4.1	**Architecture and Identity**	UNESCO 2010, Abel (1993,2000)
Local building regulations	IGBC v3 and LEED v4.1, MBBL 2016, NBC 2016 (climate specific)	**Cultural heritage**	UNESCO 2010, 2021
Local Materials	MBBL 2016	**Climate resilience construction**	UNESCO 2012, 2015, Rapoport 2006
Indoor environment quality	GRIHA v.2019, IGBC v3, LEED v4.1, NBC 2016, Chappells and Shove (2005)	**Interconnectedness**	UNESCO 2010
Construction management practices	GRIHA v.2019, IGBC v3, LEED v4.1, NBC 2016	**Inter-regional impact**	UNESCO 2010

Water management	GRIHA v.2019, IGBC v3, LEED v4.1, NBC 2016, MBBL 2016	**Cultural landscape**	UNESCO 2015
Universal Design	IGBC v3	**Cultural access, participation, and consumption**	UNESCO 2010
Accessibility	IGBC v3	**Quality of life**	Jackson, M. R., Herranz, J. (2002)
Signage	NBC 2016	**Spirituality**	Al-Jokhadar, A., & Jabi, W. (2016).
Safety	GRIHA v.2019	**Cultural Identity**	Al-Zubaidai (2007)

Sustainability is a vital part of both intangible and tangible resources. Socio-cultural factors are merely proposed rather than explicitly stated in most standards. However, the building's architectural characteristics alone do not place it in its proper setting. The housing design should characterize social, aesthetic, and environmental concepts and include all fundamentals for forming an indoor space that would satisfy the lifestyle of people or the community. Dohr and Portillo, Oliver, and Rapport established that the tangible and intangible indicators are inseparable in creating contemporary and vernacular architecture alike and thus are essential for a regional and eco-cultural approach (Oliver, 1997; Rapoport Amos, 1969)(Portillo & Dohr, 1994). Anthropologists can teach us more about cultures' intangible abstractions, but their distinct social, functionalist, cultural, economic, and other emphases must be acknowledged. Language and religion are cultural characteristics that need not be physically manifested (Oliver, 1997).

From the above frame, the study clearly shows that social and cultural indicators are not a considerable part of the policy database. These indicators are mentioned in the green building rating systems and have been introduced in recent versions. Cultural indicators are only considered a concern by UNESCO and some scholars. Green building assessment methods appear to have the same bias toward physical metrics related to energy, environment, and resources. There is a little reference for the socio-cultural aspect of sustainability in these documents; the study has discussed these indicators through other existing literature.

2.4.1. Tangible and Intangible Indicators

The fourth section highlights the interpretation of selected indicators from resources discussed earlier in the paper. To accomplish the required social and cultural indicators, the study comprehended how these indicators are developed over a period and proceeded with the best possible indicators suited to our scenario. The term social relates to a group of people and community, and culture relates to how people go about certain things that result in perception built up and developed. This study establishes a set of feasible indicators and their interpretation, which can be used to create a framework focusing on the socio-cultural aspect of housing and are reflected in Table 2.12.

2.4.1. Relationship between indicators

Through this in-depth study, the researcher selected a few representative attributes that cover sustainable assessment's social and cultural aspects. These attributes were selected based on their relationship with the built environment and their mention of national guidelines and global reports. Figure 2.9 depicts the conceptual framework developed regarding social and cultural indicators. The smaller bubble here represents the broader attributes or zones of social and cultural aspects, and the rectangular box denotes the qualities of these attributes.

E.g., For special provisions: the pointers are a senior citizen and child care and signage. The other textual information shown in different colors could be a combination of two aspects like, socio-economic or eco-cultural, etc.

Table 2.12 Selected Social And Cultural Indicators And Their Interpretation

S.no.	Social Indicator	Interpretation	Cultural Indicator	Interpretation
1	Local Priority	For consideration of local material usage and construction techniques	Visual and Aesthetic	Relevance of the element w.r.t. form, color, and functionality
2	Proximity to amenities	Nearness to the neighborhood, services, public spaces, and transportation	Cultural spaces	Based on ideology or belief of a place
3	Special Provision	Facilitates for elderly, child care, and disabled people	Hierarchy of spaces	Privacy and space segregation within the area
4	Awareness about sustainability	Knowing and responding to environmental awareness	Adaptability	Usage and utility of the environment and space
5	Safety	Sense of security within the premises and neighborhood areas	Satisfaction level	Gaging level of satisfaction within the space
6	Resident comfort	The well-being of the people w.r.t. interior environment	Cultural relevance	Understanding and responding to space

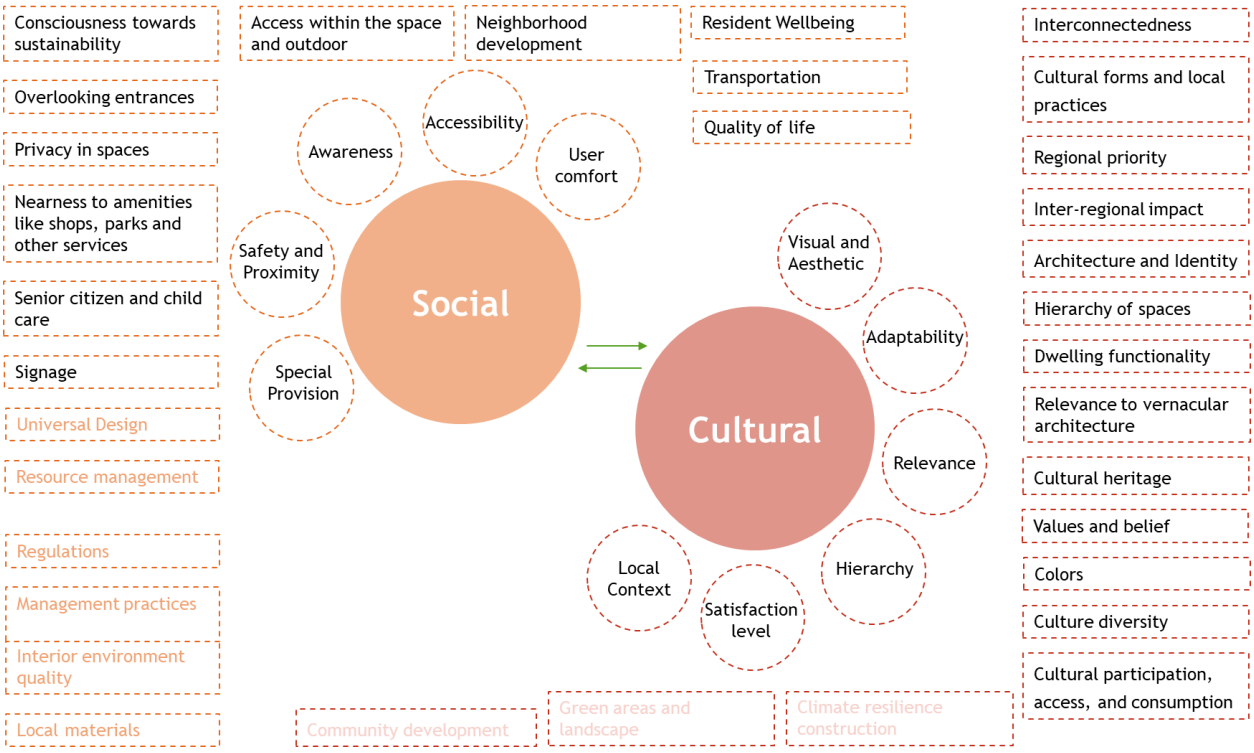

Figure 2.9 Represents Measurements To Achieve Sustainability On Social And Cultural Sides.

2.5. Chapter Conclusion

India is so diverse in culture and traditions and has distinctive climate regions. It needs a tailor-made approach or regional tactic to address specific challenges. The location changes in material type, availability, practices, architectural styles, dwelling types, belief systems, etc. Hence, local solutions and approaches can sustain more here. In this study, the researcher realized that almost no parameters directly focus on the cultural aspect of sustainability. After holding a robust identity and being well-rooted in the lives of Indian people, it is still neglected. There is a need to add more social and cultural parameters suited to Indian typology. This study will contribute to identifying tangible and intangible aspects of the residential sector. The study can help researchers understand the energy policy outlook and the multiple reforms that drive them. It also gives them an understanding of how social and cultural factors are incorporated in existing systems—need inter-ministerial policies and multi-disciplinary development programs for developing a sustainable

environment from all dimensions. After the study, the researcher analysed that it is viable to identify, recognize and select social and cultural indicators. The sustainability domain requires more local interventions and involvement to identify location-specific requirements targets and advance state-level policies and reforms.

After an in-depth study of the parameters of Indian green building assessment methods and social and cultural sustainability, the study could infer the presence and possibility of identifying tangible and intangible aspects in both categories. All the required information about these indicators is collected using explanatory documents and their portals. The rating systems are directed toward social, economic, and environmental factors. Detailed studies of policies, scholarly databases, and reports are required for intangible aspects. Piparsania, in her research, highlighted how social and cultural elements are integrated into existing systems and that it is viable to identify, understand and implement these social and cultural indicators for a better sustainable approach (Piparsania K & Kalita, 2021). To achieve social and cultural indicators, the process must comprehend how they are developed over time and how they have proceeded with the best possible indicators suited to our scenario. Table 2.13 represents the indicators extracted during the literature study for each aspect.

Table 2.13 List of Indicators

Indicator	Indicator from literature	Indicators for green building rating systems
Social	Senior Citizen and Child Care, Resident Well-Being, Transportation, Neighborhood Development, Local Materials, Universal Design, Accessibility, Signage, Safety, Awareness, Proximity to Services and Amenities, Privacy and Safety Measures, Disability Needs, Satisfaction Level	Education and Awareness, Surrounding Density and Diverse Uses, Neighbourhood Development, Facility for Physical Well-being, Visual Comfort, Universal Accessibility, Positive social impact
Cultural	Regional Priority, Cultural Forms, and Local Practices, Culture Diversity, Architecture and Identity, Interconnectedness Inter-Regional Impact, Quality of Life, Dwelling Functionality, Visual and Aesthetics, Cultural Spaces, Hierarchy of Space, Adaptability, Cultural Relevance	Regional Priority
Environment	Waste Management: Construction And Solid Waste, Hazard Prevention, Recyclable Materials, Green Areas and Vegetation, Use Of Locally Available Materials And Technology, Renewable Energy	Site and topography, Water Management, Energy Efficiency, Air Quality, Renewable Energy, Rainwater Management, Waste Management, Alternate Material, Construction management,
Economic	Affordability and Durability, Policy and Regulations, Optimization Of Energy and Operations, Local Building Regulations, Economic Viability	Energy Monitoring, Life Cycle Costing, Operation, and Maintenance Protocol, Performance metering

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Chapter 3

RESEARCH METHODOLOGY:

Methods and Survey Results

3. RESEARCH METHODOLOGY: Methods and Survey Results

3.1.Introduction

The research plan has five major phases, showcased in Figure 3.1 below. Phase one of the study starts with context analysis, including formulation and research gap findings. The second step involves secondary research based on the current context, in-depth studies on sustainability, housing, energy policies and standards, green building rating systems, and understanding social and cultural indicators. The third step comprises primary research, involving in-depth interviews for the pilot study, requirement prioritization, user study as a part of survey research for occupants, and understanding their view towards integrating socio-cultural indicators in housing. The final phase leads to developing a holistic and balanced framework for sustainable design assessment.

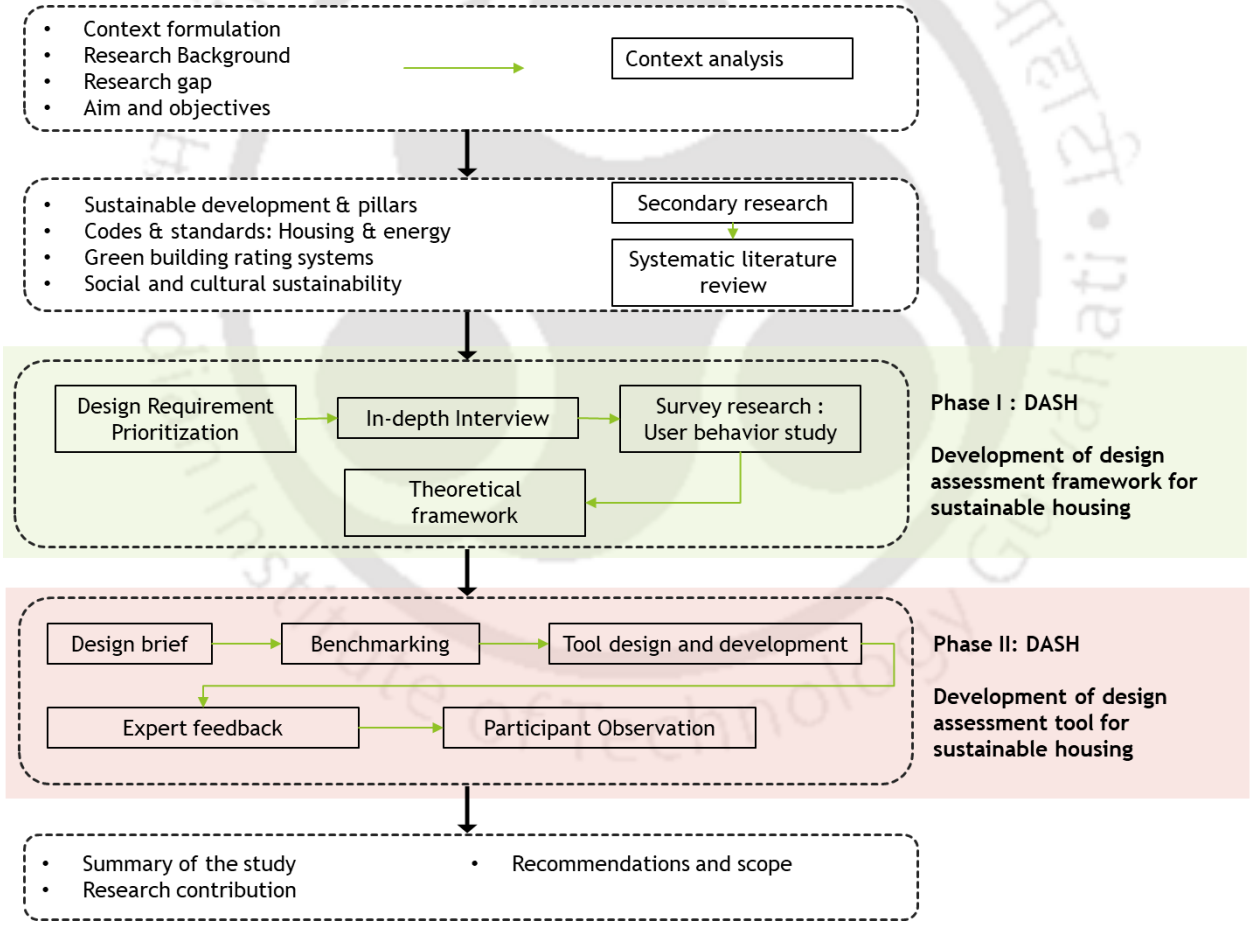

Figure 3.1 Research Methodology for DASH

3.2.Research Methodology

The research methodology has been explained in detail with the help of Table 3.1, shown below.

Table 3.1 Stages of Research

Stages	Research Question	Design Method	Research Methodology
Preamble		Context analysis	Establishing the context and background for research. Identifying relevant gaps reaches aims and objectives with the help of existing literature in journal publications, reports, books, and other relevant published sources.
Literature Review	What are the indicators for social and cultural aspects of housing?	Secondary research: Systematic literature review	Secondary data is reviewed through a systematic literature review on areas of sustainability and three pillars, global and Indian context on sustainable development, housing, social and cultural aspects of housing, green building rating systems in developed and developing countries, building standards and codes, housing and energy policies and related concepts.
	Which social and cultural indicators are more relatable?		
	How do these socio-cultural indicators connect with the built environment?		
	Which sustainable design assessment tools are available in developed and developing countries, and how have they		

	integrated socio-cultural indicators?		
	How to incorporate socio-cultural aspects into green building assessment methods for housing?		
Phase I : Development of design assessment framework for sustainable housing	What is the occupant's perception of integrating socio-cultural indicators in housing?	Design Requirement Prioritization	The main goal here is to prioritize the inclusion of social and cultural indicators. Identifying the key categories influencing the sustainability of residential buildings, establishing the priority weight for dimensions and categories, and integrating social and cultural dimensions along with the environment and economic in building sustainability assessment. Incorporating user needs and their perception towards sustainability and its indicators.
		In-depth Interview	A pilot study is conducted at the initial stages to understand the questionnaire's scope, the user's behavior response, and their understanding. An open-ended comprehensive interview is conducted to obtain detailed information about a context from the participant. The aim is to understand the respondent's in-depth point of view, experiences, and perspectives. The duration of each

			call/interview is approximately around 30-45 mins.
	How to involve occupants and their participation in sustainable design assessment?	Survey research: User behavior study	Residents' and occupant's requirements were collected with the help of a structured questionnaire based on the survey method. The data is analyzed using graphs and statistical analysis to observe significant co-relations between identified variables. The data collected were formulated and analyzed using SPSS 20.0 statistical software. A total of 133 participants responded and contributed their views to the study.
	How to develop a holistic and balanced framework for sustainable design assessment?	Theoretical framework	A theoretical framework focuses on identified variables and defining the specific viewpoint formulated from the user behavior study and secondary data.
Phase II: Development of design assessment tool for sustainable housing	How to translate the developed framework into a tool?	Design Brief	To translate the developed framework into an assessment tool with the help of existing green building guidelines and assessment methods.
		Benchmarking	Standard practices are considered a point of reference for the benchmark study. Building codes and policies, green building rating systems, and government

			reports that are accessible and available to the general public for reference are considered.
		Product development Process: Tool design and development	The entire tool is designed and developed in a spreadsheet format using Microsoft Excel version 2019, and multiple standards and guidelines are reviewed to establish a proper context. The navigation, ease of use, and content are simplified using formulas and function control. Consistency and standard protocol have been maintained throughout for easiness and reduction of error.
		Performance Testing: Expert feedback: Convenient Sampling Method	The tool was e-mailed to the Industry experts before the feedback. In-depth discussions, and feedback are taken over phone calls, with a duration range of 45-60 mins. After reviewing the tool, the respondents are further asked to fill out a feedback form, shared in the form of a structured questionnaire.
		Performance Testing: Participant Observation	The additional validation was conducted to enhance the user experience of the tool, followed by open-ended and closed-ended questions. The testing was conducted in two phases for different groups; for versions 1 and 2. The tool

			was gauged through heuristics principles.

3.3. Questionnaire Development And Reliability

The requirement was set established to find and validate social and cultural indicators. The survey-based data collection is divided into two major parts: conducting a pilot run to validate the questionnaire and checking its reliability. The data collection process utilizes a set of open-ended and semi-structured inquiries. The occupants were also asked to rate their views on selected indicators using a Likert scale. The document also has the option to upload images of the house for better understanding. The second phase deals with data collected through the survey. Initially, the data collection was a field-based study plan consisting of in-depth interviews and ethnographic research. However, due to the pandemic situation and circumstances of the COVID-II wave in India, the data is gathered using google forms.The questionnaire was circulated online through personal emails and other social media platforms, and the nature of the interview changed to video calls. The data collection process utilizes a set of structured inquiries during the survey. The users were also asked to rate their views on selected indicators using a Likert scale. As the research must represent broader cases to provide more insight into the socio-cultural aspect, the selected studies represent modern and vernacular housing development approaches.

Initially, a pilot study was conducted to understand the questionnaire's scope, the user's response, and understanding. The study was conducted with a limited set of people from different cities in India. A group of questions, type of option selection method, and a small part of demographic data collection are revised based on respondents' feedback, and a revised questionnaire is prepared. The questionnaire framework is shown in Figure 3.2. Before conducting the survey, the questionnaire was verified under a reliability test using Cronbach's Alpha through SPSS. The alpha value reaching the subjective value of 0.70 represents an adequate measure of reliability (Taber, 2018). The resulting value output received was .736 in this case.

3.4.Phases and Methods in data collection

3.4.1. Pilot study

Initially, a pilot study was conducted to understand the questionnaire's scope, the user's response, and their understanding. The study was conducted with a limited set of people from different cities in India. A group of questions, type of option selection method, and a small part of demographic data collection are revised based on respondents' feedback, and a revised questionnaire is prepared. A detailed questionnaire can be found in the annexure section. The pilot study was conducted with five people from five different cities: Ahmedabad, Guwahati, Gurgaon, Bundi, and Nagpur. Figure 1.3-1.9 depicts the demographic information collected from the participants. All the participants are aged between 18 – 30 years, employed, and have a certain understanding of architecture and the built environment.

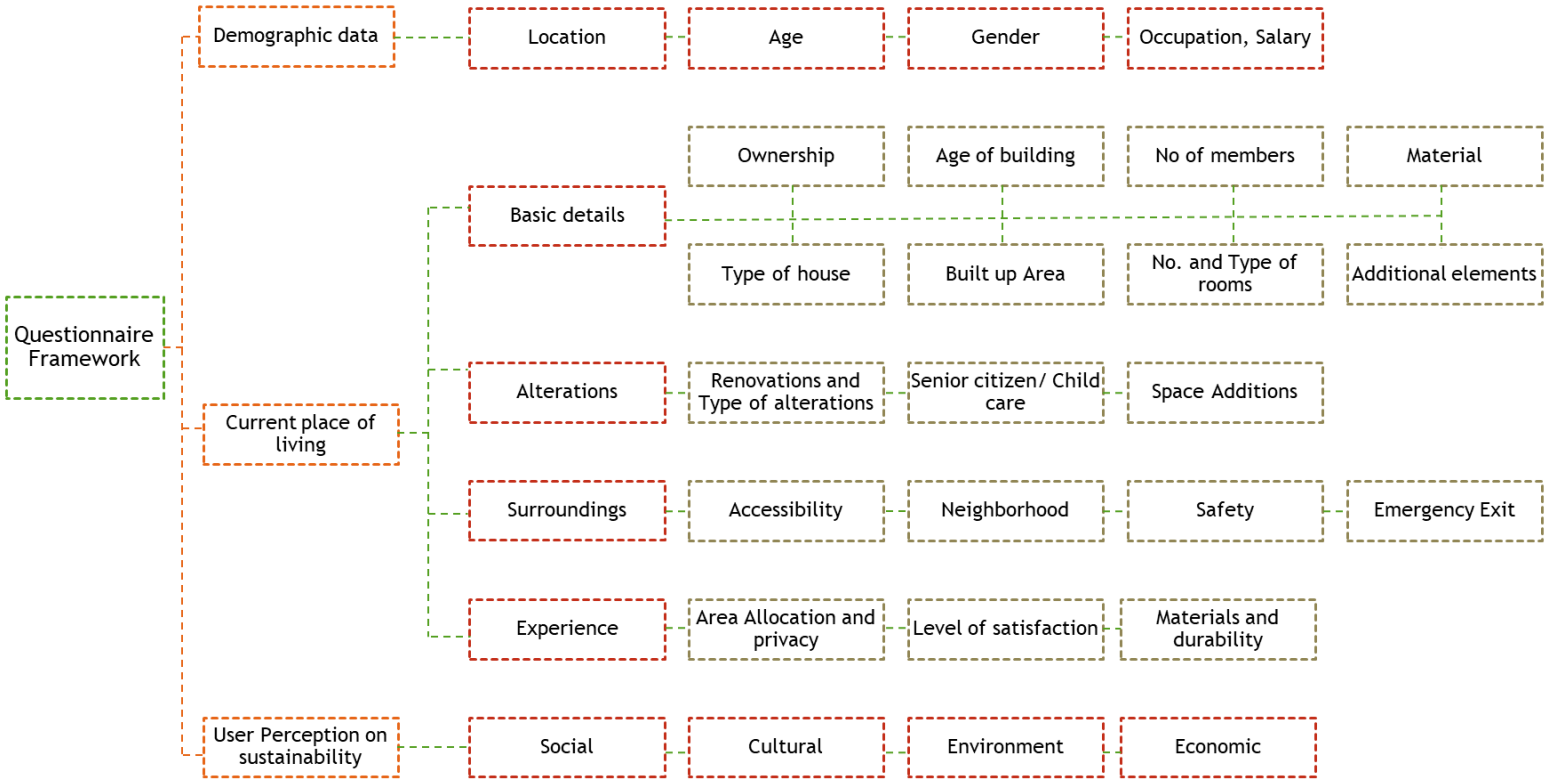

Figure 3.2 Framework for Questionnaire Design

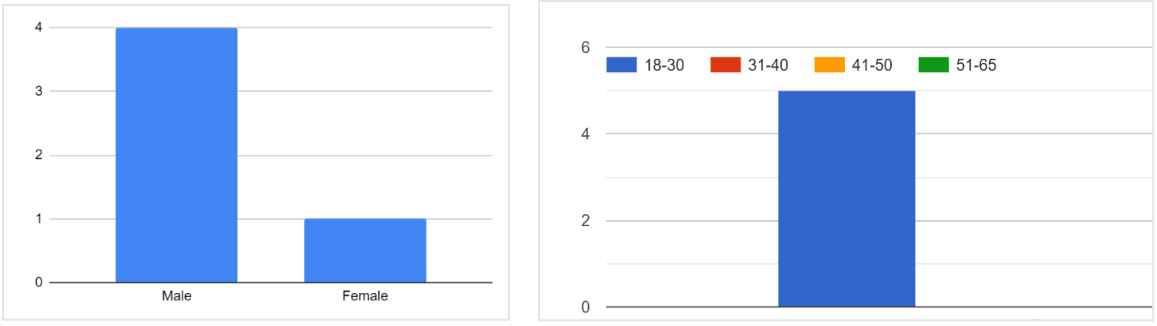

Figure 3.3 Survey Outcome On Gender And Age Range Of Occupants

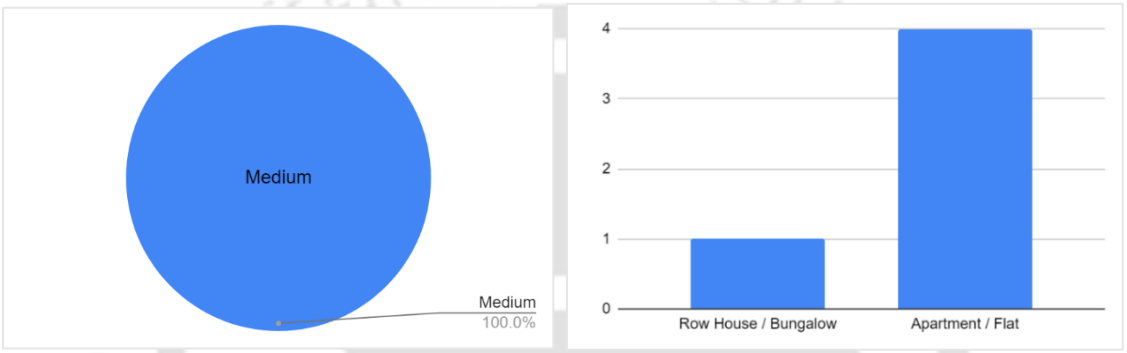

Figure 3.4 Survey Outcome Income Group Of The Occupants And Their Type Of House.

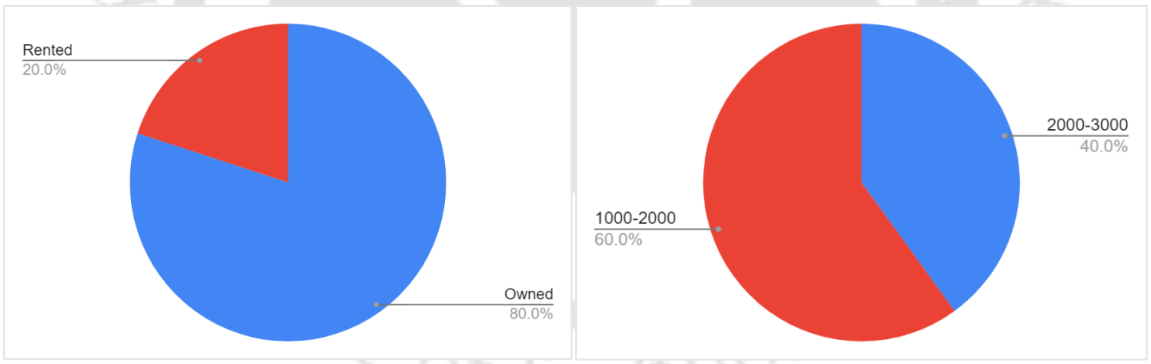

Figure 3.5 Survey Outcome On Type Of Ownership And Built-Up Area Of The House.

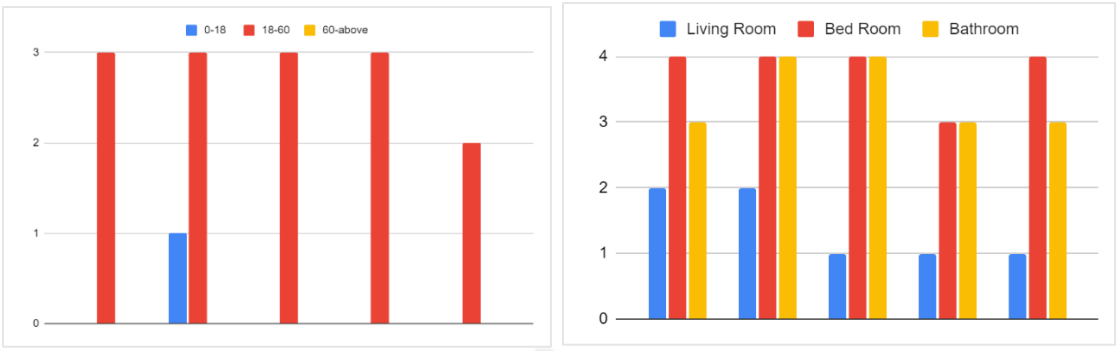

Figure 3.6 Survey Outcome On Number Of Family Members And Type Of Rooms.

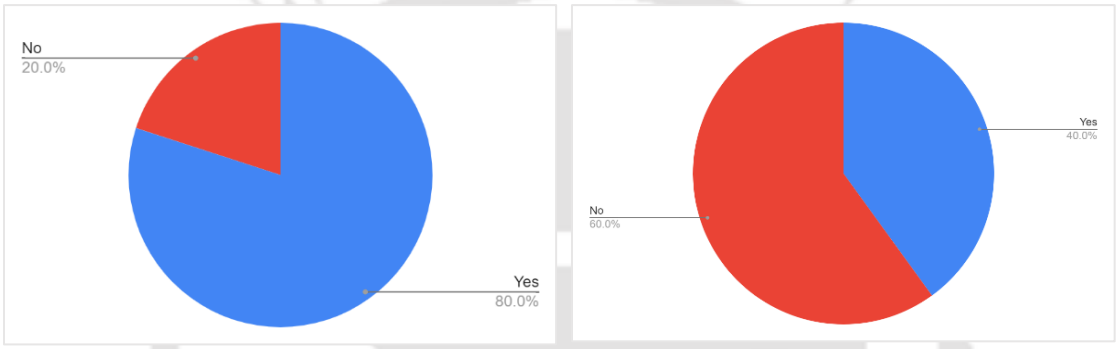

Figure 3.7 Survey Outcome On Preference For Renovation And Provision Of Additional Space.

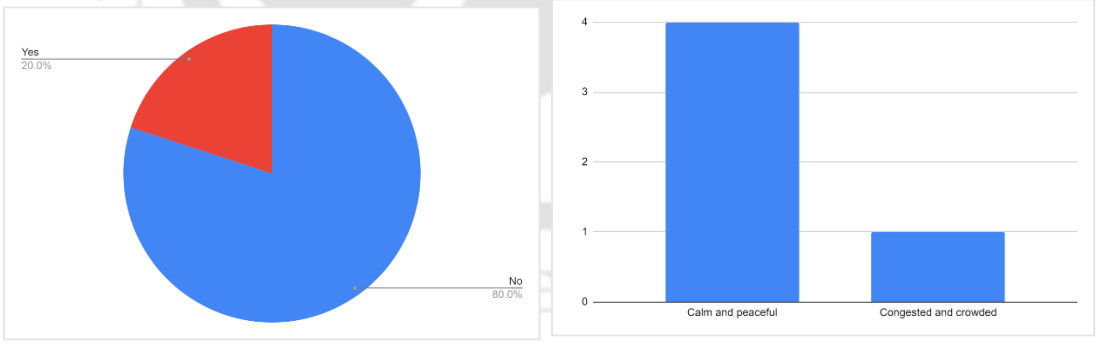

Figure 3.8 Survey Outcome On Alterations Made For Kids/ Senior Citizens And Feelings Regarding The Vicinity

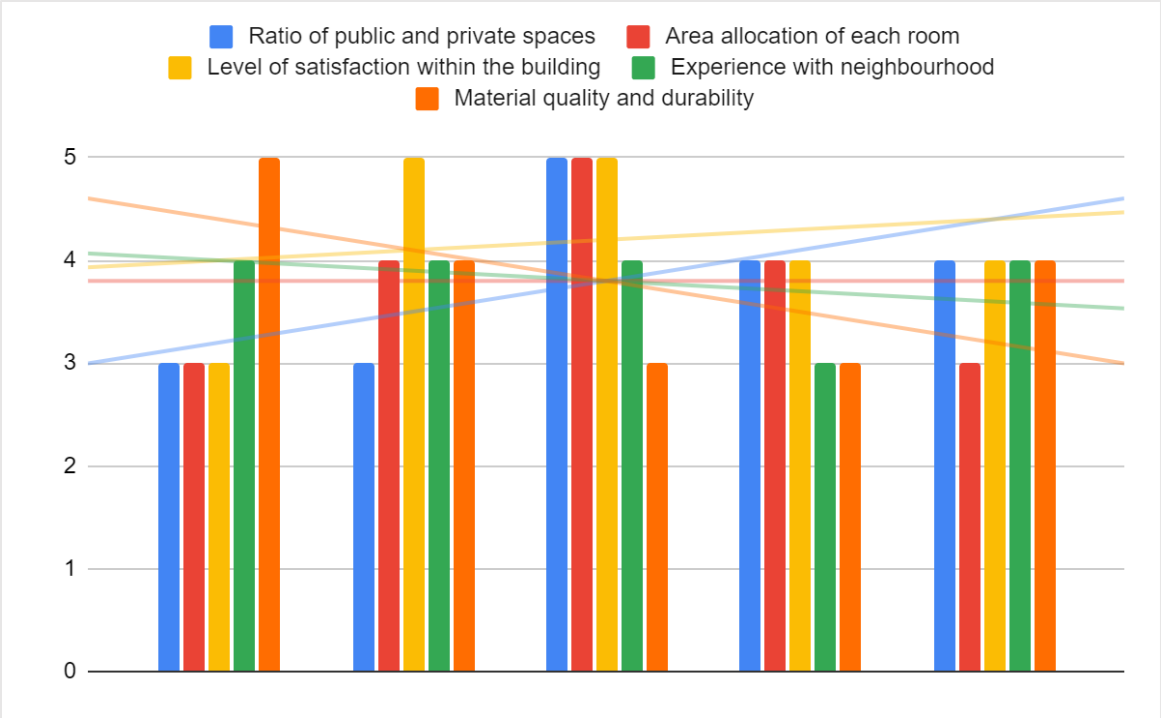

Figure 3.9 Survey Outcome On Occupant's Perception Of Existing Housing Scenario.

Table 3.2 depicts the feedback of the respondents.

Table 3.2 Feedback of the Respondents

Criteria	Demographic Data	Existing house	User Perception	Overall Feedback
Case 01	To increase the number of family members and no of rooms, one could select	Add more options under renovation. Elaborate on row houses and bungalows	A few questions seemed similar/ repetitive, couldn't comprehend the purpose	Limit responses to 1 and add an email address.
Case 02	To increase the number of family	Multiple selection criteria in renovation	To include questions related to the	Easily understandable,

	members, and house room details, one could select	and social interaction space	economic perspective	can add more lines over the introduction and explain the intent. Collect email address
Case 03	To increase the range in the selection of family members	Include a NO option and multiple selections for social interaction space; include mandir as an element	Include questions on affordability and awareness	Lessen the no of questions to make sure that interest remains. Limit response to 1
Case 04	To increase the range in a selection of family members and elaborate income group.	To increase the range in selection in renovation (MCQ). Elaborate on terms like the neighborhood, open space, and social interaction space.	No doubts in this section.	Make the upload picture option non-mandatory
Case 05	Increasing the range in the selection of income groups makes it easier to fill in.	Elaborate on public to private spaces	No confusion in questions; I could answer everything.	Easy to understand, no repetition.

Questions and option selections are revised based on the feedback of surveyors. A newly revised questionnaire is prepared, and a questionnaire reliability test is conducted further.

Table 3.3. Modifications as per the feedback of the respondents

S.no.	Demographic Data	Existing house	User Perception
01	Increased the section range for family members, no of rooms	Multiple selection criteria included in the renovation, social interaction space and no. of elements in the home	Rephrased the statements which showed common attributes
02	Increased options for the income group range	Included more options under renovation, social interaction space and elements in the house	Altered a few statements and combined them, which stated the same goal.
03	Added description on the question about building age	Rephrase the question about neighborhood and child care.	Added statements about economic and environmental aspects
04	Included collection of email addresses and limited response to 1	Added an option where respondents can add other details about their house.	Attempted to cover all aspects mentioned under various literature and scholarly articles
05	Added an option "other "in option selection questions	Made the upload picture criteria non-mandatory	Made it mandatory to answer all questions

The process utilizes a set of open-ended and semi-structured inquiries during the data collection. Ethical consent was taken from all the participants in case of recording voices and videos and collecting any other data before the interview or data collection. Before filling out the questionnaire, the respondents will be informed of the survey's intent and objectives. The participation of respondents in this study is voluntary.

The survey form shall contain a set of questions with options to choose from the group. The document also has the opportunity to upload images of the house for better understanding. All participants were informed of inclusion and exclusion criteria beforehand that they must be present

residents of India, be over age 18, and have any gender, employment area, or economic background. It is all right, even if they do not want to disclose their gender type, employment, or personal information. The data collection and analysis segment is divided into three major phases, as shown in Figure 3.10.

After revising the questionnaire as per the feedback, the framework is developed for data collection and analysis. The methodology is divided into three phases and is showcased in the figure.

3.4.2. Survey And Data Collection

The occupants were initially briefed about the study's motive and goals and, more importantly, how it will utilize the information shared at the beginning of the data collection. The relevant occupants were identified based on the convenient sampling method. A total of 133 residents participated in the survey. The entire data was visualized using multiple graphs and charts. The users were also asked to rank their perceptions of selected indicators using a five-point Likert scale. A detailed questionnaire regarding the survey can be found in the annexure section. A list of tangible and intangible indicators related to existing and ideal housing scenarios was shared for this analysis. The indicators are expressed to the users in informal statements and are not directly presented. A flow chart depicting the questionnaire guide is represented in Figure 3.2.

Initially, an ethnographic approach was adopted to collect data and understand the occupants' perceptions. Due to Covid-19, the strategy had to be modified, and a survey-based method was selected. All the occupants were assumed to inherit some prior knowledge regarding the built environment and construction methods.

3.4.3. Data Analysis

The following graphs, figures 3.11 - 3.21, below depict the nature of the data collected and their responses. This graphical data is related to demographics and the current housing of the occupants.

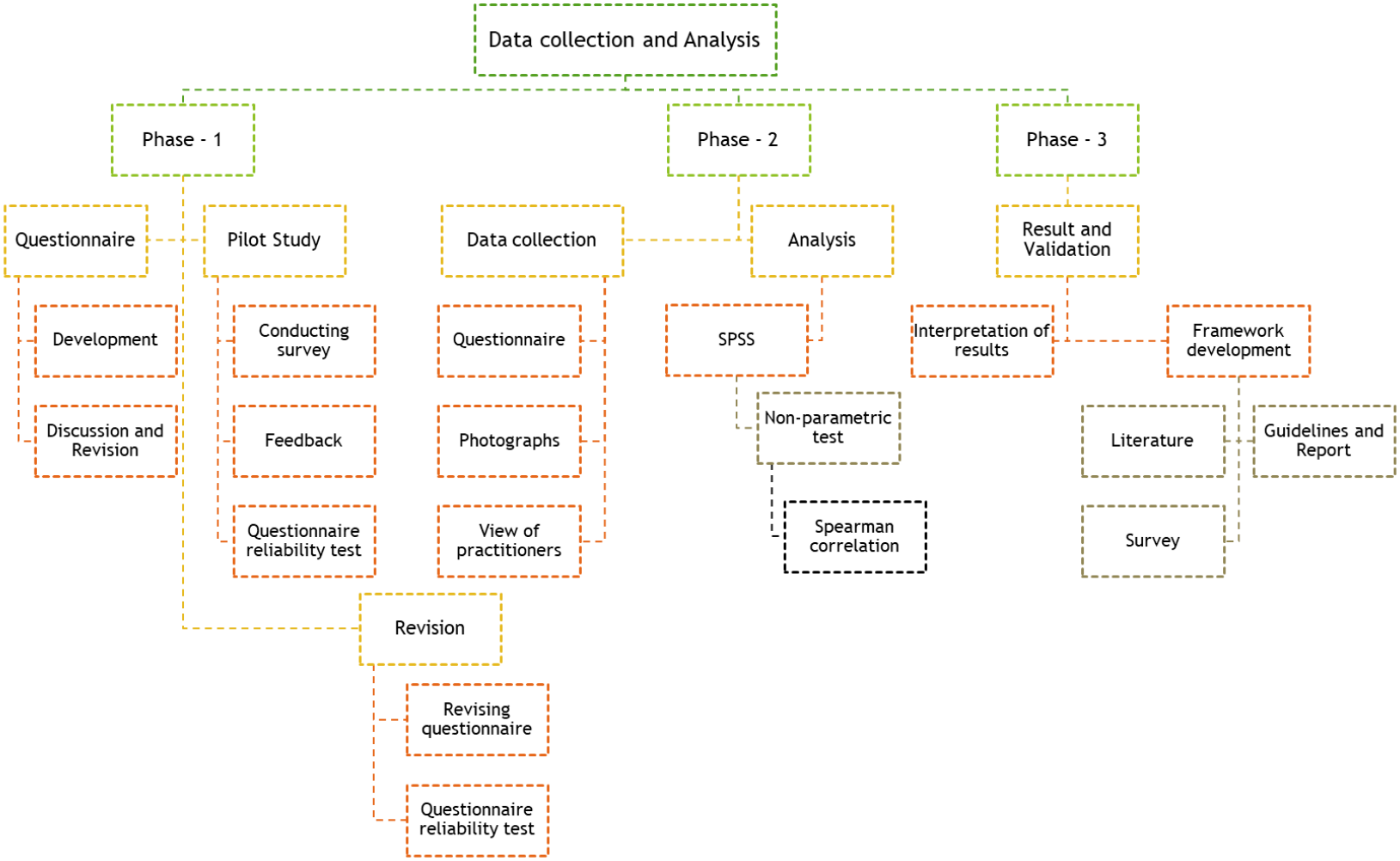

Figure 3.10. Flow Chart For Data Collection And Analysis

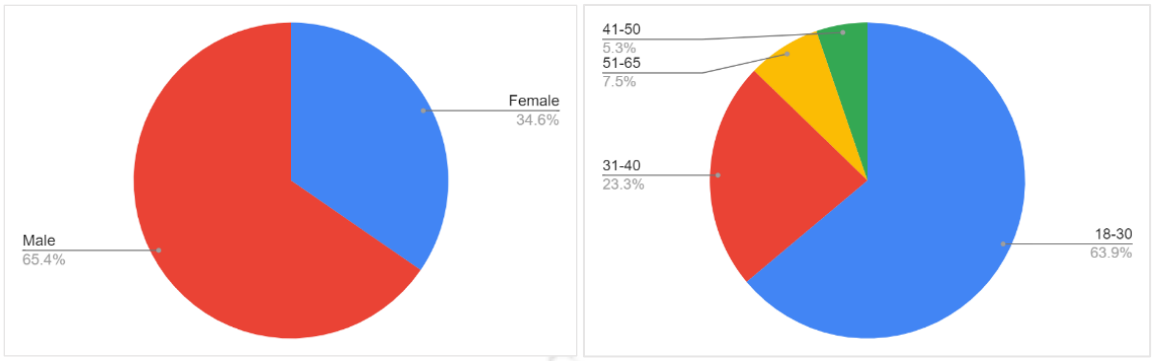

Figure 3.11 Survey Outcome On Gender And Age Range Of Occupants

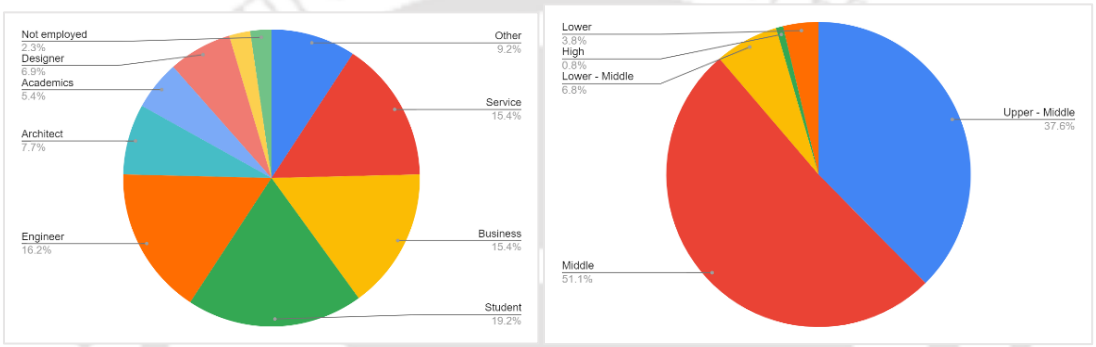

Figure 3.12 Survey Outcome On Occupation Type And Income Group Of The Occupants

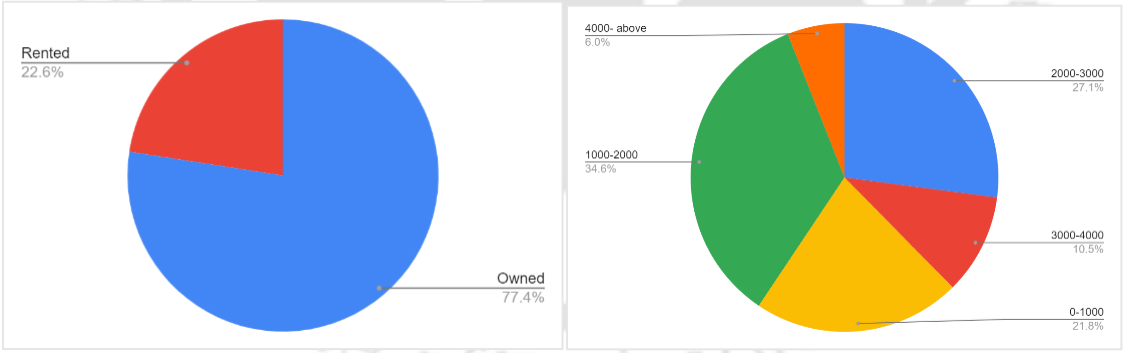

Figure 3.13 Survey Outcome On Type Of Ownership And Built-Up Area Of The House.

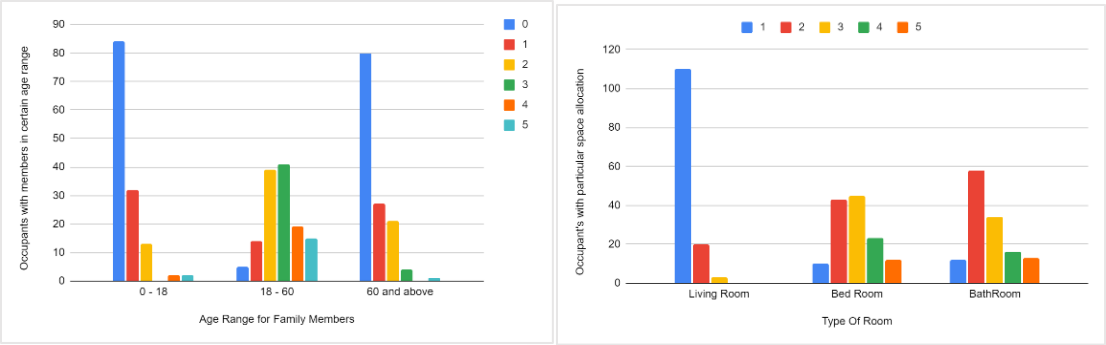

Figure 3.14 Survey Outcome On Number Of Family Members And Type Of Rooms.

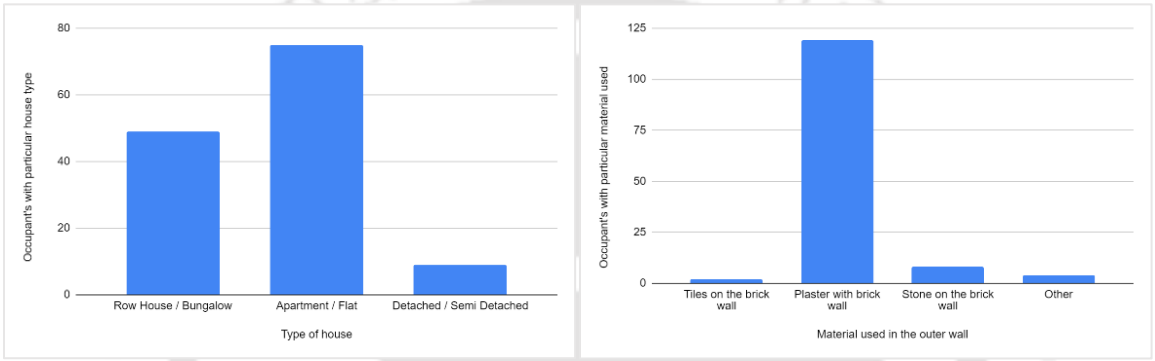

Figure 3.15 Survey Outcome On The Type Of House And Material Used On The Outer Wall.

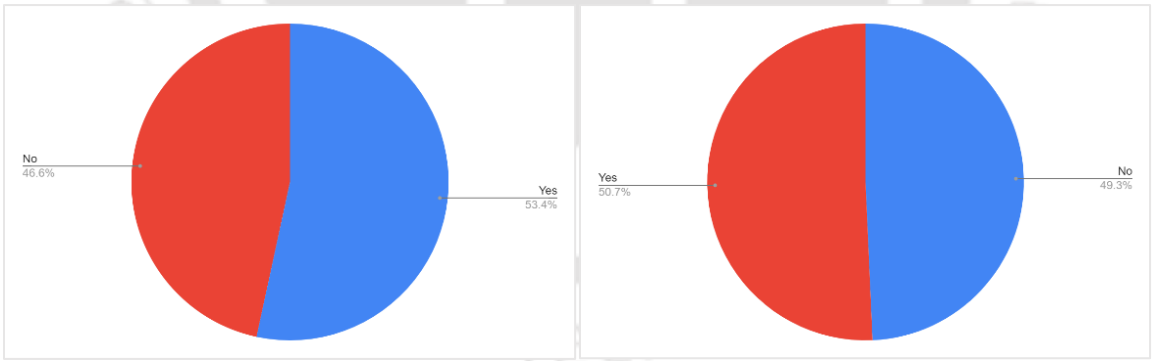

Figure 3.16 Survey Outcome On Preference For Renovation And Provision Of Additional Space.

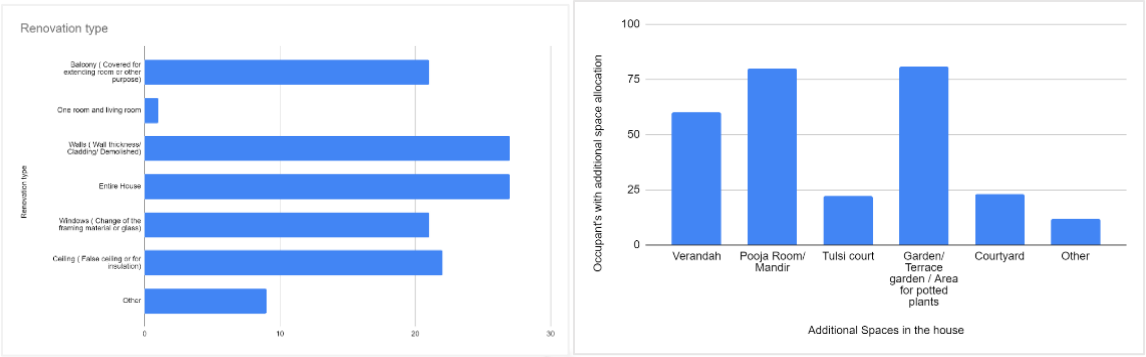

Figure 3.17 Survey Outcome On Renovation Types And Type Of Additional Spaces.

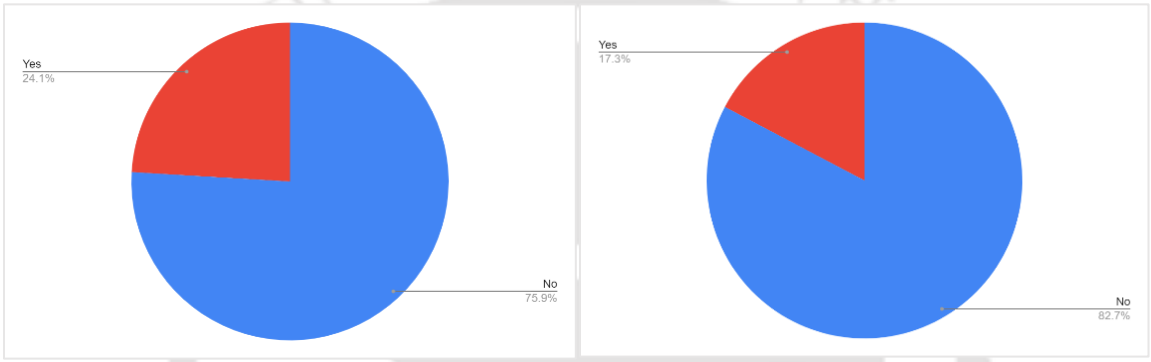

Figure 3.18 Survey Outcome On Alterations Made For Kids/ Senior Citizens And Discomfort Faced In Daily Activities.

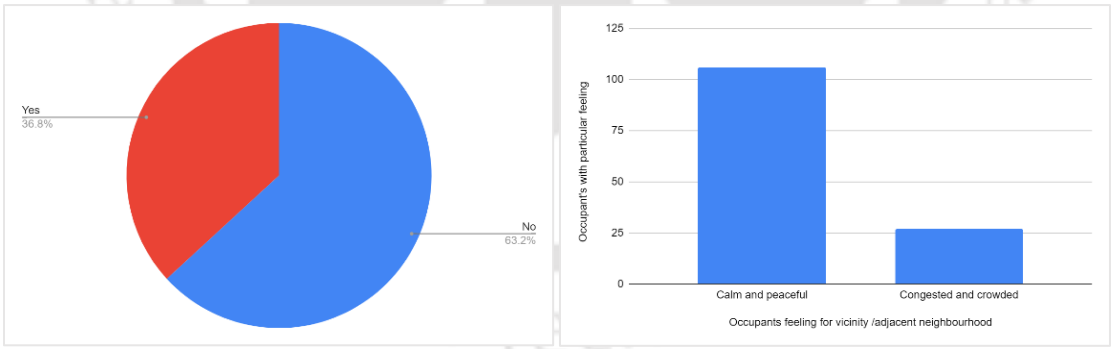

Figure 3.19 Survey Outcome On The Provision Of Emergency Exit And Feelings Regarding The Vicinity

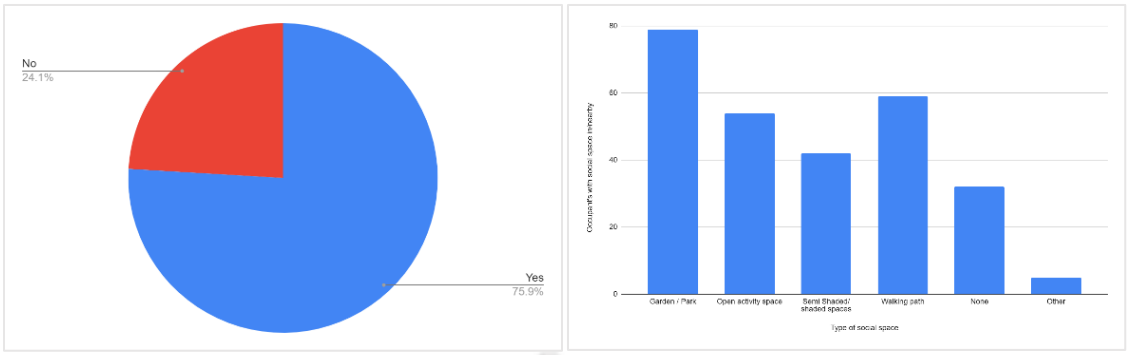

Figure 3.20 Survey Outcome On The Provision Of Social Space And Type Of Social Space.

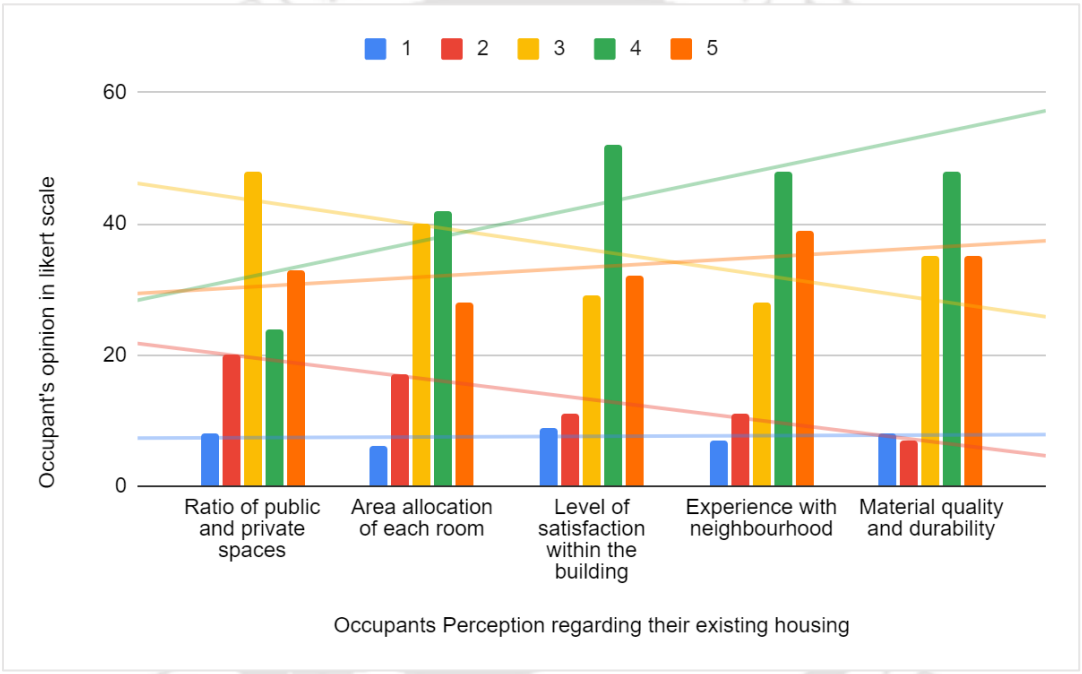

Figure 3.21 Survey Outcome On Occupant's Perception Of Existing Housing Scenario.

3.5.Data Testing

3.5.1. SPSS Correlation

Data analysis was directed by survey analysis in the form of graphical charts and further analyzed with SPSS Statistics software. Survey analysis allowed the interpretation of raw data collected into insightful information. After the review, the indicators were re-analyzed, and selected indicators were taken forward to understand their co-relation.

Using the SPSS software, data is categorized into variables, and the values are coded (Mackridge & Rowe, 2018). Spearman's rho is a common technique for connecting survey questionnaires or Likert-type survey responses. The Spearman correlation is a nonparametric measure of the strength and direction of association that exists between two variables measured on at least an ordinal scale, which in this case were tangible and intangible indicators (Mackridge & Rowe, 2018). The resultant values for Spearman's correlation after conducting the test range from 0.0 – 1.0, and their interpretation are as follows: $0.0 \leq \rho \leq 0.2$ - Very Weak Agreement/Co-relation, $0.2 \leq \rho \leq 0.4$ - Weak Agreement/Co-relation, $0.4 \leq \rho \leq 0.6$ - Moderate Agreement/Co-relation, $0.6 \leq \rho \leq 0.8$ - Strong Agreement/Co-relation and $0.8 \leq \rho \leq 1.0$ - Very Strong Agreement/Co-relation (Mackridge & Rowe, 2018).

The results in Figure 3.22 show a connection between all the variables, representing low, moderate, and strong relationships, color-coded with yellow, blue, and green. This test further establishes the correlation between all variables. Apart from two categories (Continuity in building style for a community and locally available materials and technology), which are linked with only seven variables and others related with 12, the others can be seen connected with at least 16, which exceeds 19 categories for nine variables.The indicators are initially established, denoting social and cultural aspects of sustainable design through the literature study. After the survey and data analysis (co-relation testing), the comprehensive research could validate the relationship between these indicators. Figure 3.23 showcase the list of indicators considered for the study to develop the framework and their co-relation values.

Particulars	Locally available materials and technology	Continuity in building style for a community	Visual privacy to principal areas of house	Maintaining hierarchy of spaces	Flexibility to customize /renovate the house	Abide to compliance	Common meeting areas or interactive spaces	Reflection of cultural values and beliefs	Architectural connect with local identity	Ease of accessibility to spaces	Special Provision	Less operational and maintenance cost	Provision for safety and security	Ample daylight and ventilation	Low Noise Transmission	Provision for rain water harvesting	Affordable management practices	Renewable energy source/ passive design	Sharing ideas about sustainability	Proximity to local services and transportation
Use of locally available materials and technology during construction	1.000	0.541	0.506	0.364	0.342	0.413	0.457	0.405	0.392	0.413	0.304	0.395	0.403	0.366	0.393	0.364	0.403	0.509	0.553	0.445
Continuity in building style for a community	0.541	1.000	0.497	0.441	0.353	0.366	0.383	0.338	0.271	0.358	0.332	0.416	0.379	0.335	0.329	0.430	0.337	0.363	0.406	0.330
Visual privacy to principal areas of house	0.506	0.497	1.000	0.466	0.536	0.576	0.517	0.462	0.449	0.538	0.364	0.480	0.521	0.502	0.584	0.491	0.515	0.526	0.522	0.586
Maintaining hierarchy of spaces	0.364	0.441	0.466	1.000	0.439	0.512	0.515	0.377	0.432	0.489	0.459	0.403	0.489	0.474	0.479	0.430	0.419	0.351	0.348	0.527
Flexibility to customize/renovate the house	0.342	0.353	0.536	0.439	1.000	0.766	0.518	0.572	0.548	0.674	0.639	0.593	0.659	0.582	0.623	0.592	0.582	0.617	0.566	0.739
Abide to compliance	0.413	0.366	0.576	0.512	0.766	1.000	0.687	0.632	0.554	0.667	0.624	0.579	0.602	0.589	0.700	0.631	0.618	0.628	0.557	0.700
Common meeting areas or interactive spaces within premises	0.457	0.383	0.517	0.515	0.518	0.687	1.000	0.567	0.522	0.567	0.508	0.473	0.523	0.591	0.620	0.553	0.524	0.641	0.569	0.591
Reflection of cultural values and beliefs	0.405	0.338	0.462	0.377	0.572	0.632	0.567	1.000	0.636	0.613	0.469	0.499	0.453	0.471	0.575	0.484	0.478	0.537	0.518	0.592
Architectural connect with local identity	0.392	0.271	0.449	0.432	0.548	0.554	0.522	0.636	1.000	0.643	0.506	0.525	0.431	0.422	0.578	0.584	0.513	0.613	0.581	0.654
Ease of accessibility to spaces	0.413	0.358	0.538	0.489	0.674	0.667	0.567	0.613	0.643	1.000	0.626	0.657	0.696	0.582	0.649	0.662	0.628	0.636	0.643	0.727
Special Provision	0.304	0.332	0.364	0.459	0.639	0.624	0.508	0.469	0.506	0.626	1.000	0.672	0.547	0.609	0.499	0.504	0.569	0.441	0.392	0.594
Less operational and maintenance cost	0.395	0.416	0.480	0.403	0.593	0.579	0.473	0.499	0.525	0.657	0.672	1.000	0.728	0.614	0.713	0.627	0.657	0.572	0.482	0.663
Provision for safety and security	0.403	0.379	0.521	0.489	0.659	0.602	0.523	0.453	0.431	0.696	0.547	0.728	1.000	0.726	0.702	0.615	0.697	0.566	0.530	0.678
Ample daylight and ventilation	0.366	0.335	0.502	0.474	0.582	0.589	0.591	0.471	0.422	0.582	0.609	0.614	0.726	1.000	0.693	0.494	0.721	0.489	0.406	0.627
Low Noise Transmission	0.393	0.329	0.584	0.479	0.623	0.700	0.620	0.575	0.578	0.649	0.499	0.713	0.702	0.693	1.000	0.626	0.694	0.618	0.547	0.698
Provision for rain water harvesting	0.364	0.430	0.491	0.430	0.592	0.631	0.553	0.484	0.584	0.662	0.504	0.627	0.615	0.494	0.626	1.000	0.641	0.787	0.715	0.691
Affordable management practices	0.403	0.337	0.515	0.419	0.582	0.618	0.524	0.478	0.513	0.628	0.569	0.657	0.697	0.721	0.694	0.641	1.000	0.640	0.571	0.669
Provision to add a renewable energy source/ passive design measure	0.509	0.363	0.526	0.351	0.617	0.628	0.641	0.537	0.613	0.636	0.441	0.572	0.566	0.489	0.618	0.787	0.640	1.000	0.802	0.685
Sharing ideas about sustainability	0.553	0.406	0.522	0.348	0.566	0.557	0.569	0.518	0.581	0.643	0.392	0.482	0.530	0.406	0.547	0.715	0.571	0.802	1.000	0.635
Proximity to local services and transportation	0.445	0.330	0.586	0.527	0.739	0.700	0.591	0.592	0.654	0.727	0.594	0.663	0.678	0.627	0.698	0.691	0.669	0.685	0.635	1.000

Figure 3.22 Spearman Co-Relation Test

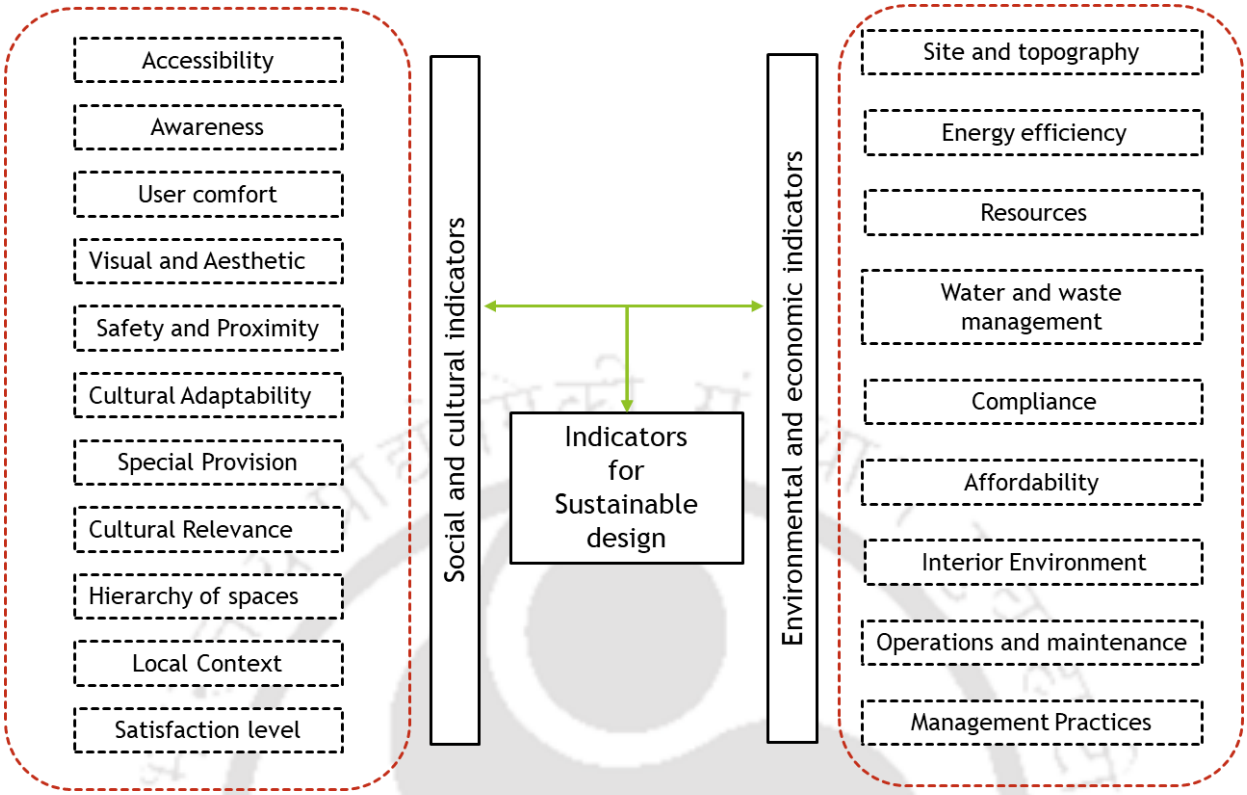

Figure 3.23 List Of Indicators That Are Considered For The Study

3.6.Limitations Of The Study

The limitations of the study are mentioned below:

- Due to Covid-19, the survey is conducted online. The questionnaire was circulated online through google forms, personal emails, and other social media platforms.
- A convenient sampling method is preferred in the initial phases of data collection.
- It wasn't easy to interpret what the participant was inferring from the questionnaire and how they responded.
- The sample size is limited due to Covid-19 prevailing in India and other restrictions like time frames, traveling restrictions, health concerns, etc.

- Fieldwork could be done in-depth, which caters to a more diversified audience to reveal more indicators and dimensions.

3.7. Chapter Conclusion

This study shows how the scope of sustainability indicators differs from the existing rating methods and frameworks. This difference could be primarily due to residents' perceptions or inclinations towards more social and cultural aspects. Another reason for the change in the scope of indicators could be a lack of awareness among occupants. In addition, occupants' responses also explain another indicator in addition to those identified in the existing literature and frameworks.

Sustainability is a vital part of both intangible and tangible resources. Socio-cultural factors are merely proposed rather than explicitly stated in most standards. However, a building's architectural characteristics alone do not place it in its proper setting. Home design should embody social, aesthetic, and environmental ideas and incorporate all necessary elements to create an indoor atmosphere that would suit an individual's or a group's lifestyle. According to Dohr, Portillo, Oliver, and Rapport, physical and intangible indicators are crucial for a regional and sustainable approach, since they are intertwined in creating contemporary and vernacular architecture. According to Abel, vernacular architecture excels at blending structures into different contexts to create a natural synergy with the climate, architecture, and individuals. Sustainable architecture is defined as architecture that is based on natural principles and environmental values and performs to meet local needs and socio-cultural systems. Subic's desktop review examined how many vernacular architectural examples and themes (such as culture, society, economy, environment, resources, and practices) relate. The evaluation techniques used for green buildings all seem to favor quantitative energy, environmental, and resource use measures.

The research approach to accomplish the primary study objectives by utilizing the primary research methods was explained in this chapter. The rationale for using a qualitative methodology for this study was discussed in the overview. Additionally, it discussed the techniques used. The chapter also described how case studies, exploratory interview techniques, semi-structured interview techniques, and participant observations were needed to fully comprehend and incorporate socio-

cultural needs into sustainable contemporary home solutions. The relationship between the research's aims, goals, and methodologies is outlined in Table 3.4. The results and a more thorough discussion of the research's conclusions are presented in the following chapters.

Table 3.4 Research Matrix

Objective	Research Question	Design Method	Chapter
To focus on socio-cultural sustainability: Merging culture as 4th pillar of sustainability/ as an extension to social sustainability.		Context analysis	One
	What are the indicators for social and cultural aspects of housing?	Secondary research: Systematic literature review	Two
	Which social and cultural indicators are more relatable?		
	How do these socio-cultural indicators connect with the built environment?		
	Which sustainable design assessment tools are available in developed and developing countries, and how have they integrated socio-cultural indicators?		
	How to incorporate socio-cultural aspects into green building assessment methods for housing?		
To find relevant socio-cultural indicators (tangible and intangible) that are user-defined.	What is the occupant's perception of integrating socio-cultural indicators in housing?	Design Requirement Prioritization	Three and Four
		In-depth Interview	
	How to involve occupants and their participation in sustainable design assessment?	Survey research: User behavior study	

To propose a balanced, sustainable design assessment framework.	How to develop a holistic and balanced framework for sustainable design assessment?	Theoretical framework	
To translate the developed framework into an assessment tool with the help of existing green building guidelines and assessment methods.	How to translate the developed framework into a tool?	Design Brief	Four
		Benchmarking	
		Product development Process: Tool design and development	
		Performance Testing: Expert feedback: Convenient Sampling Method	
		Performance Testing: Participant Observation	

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Chapter 4

RESULTS AND DISCUSSIONS:

Design and Development of DASH

4. RESULTS AND DISCUSSIONS: Design And Development Of DASH

4.1.Sustainable Design Assessment Framework

4.1.1. Defining The Framework

The study shows how the sustainability indicator's scope differs from the existing rating methods and frameworks. The difference could be primarily due to residents' perception or inclination toward more social and cultural aspects. Another reason for the change in the scope of indicators could be a lack of awareness among occupants. Besides, the occupant's responses also explain an additional indicator from those identified in existing literature and frameworks.

Sustainability is a vital part of both intangible and tangible resources. Socio-cultural factors are merely proposed rather than explicitly stated in most standards. However, the building's architectural characteristics alone do not place it in its proper setting. The home design should embody social, aesthetic, and environmental ideas and incorporate all necessary elements to create an indoor atmosphere that would suit an individual's or a group's lifestyle. According to Dohr, Portillo, Oliver, and Rapport, the physical and intangible indicators are crucial for a regional and sustainable approach since they are intertwined in creating contemporary and vernacular architecture. According to Abel, vernacular architecture excels at blending structures into different contexts to create a natural synergy with the climate, architecture, and individuals. Sustainable architecture is defined as architecture that is based on natural principles and environmental values and performs to meet local needs and socio-cultural systems. Subic's desktop review examined how many vernacular architectural examples and themes (such as culture, society and economy, environment, resources, and practices) relate. The evaluation techniques for green buildings all favor quantitative energy, environment, and resource use measures.

4.1.2. Development Of Framework

The framework comprises the three sustainability pillars with the fourth dimension of culture. The framework developed here represents practice-related components of socio-cultural sustainable building, as shown in Figure 19. The variables are derived from the existing database, which includes green building certifications, policies, and other guidelines. These documents have little

reference for the socio-cultural aspect of sustainability, so the study has discussed these indicators through UNESCO and other researchers' existing literature.The framework above showcases the indicators and interpretations of the study in a summarized form for social, environmental, economic, and cultural indicators, which have helped in the framework development. This study intends to create a socio-cultural framework for housing based on a rational collection of complementary physical and intangible variables. The social and cultural indicators of the primary research are supported by secondary data collection, which also portrays that existing sustainability frameworks and policies, evaluation tools, and guidelines lack socio-cultural elements and their integration. The study suggests a practical and implementable framework that can be merged into an existing evaluation tool or standard code. The dotted lines that connect categories to the main headings directly influence each other. The categories are derived based on the respondent's perception of sustainability concerning residential dwellings and their relationships. This framework attempts to integrate tangible and intangible aspects by combining their value with the built environment. It will also help deliver enhanced regional and area-driven sustainable developments in similar backgrounds.

The foundation of the study is based on the concept of sustainability as suggested by Brundtland Commission, which is based on three pillars: environment, economic and social. The study's first objective is to focus on socio-cultural sustainability: merging culture as an extension to social sustainability or considering culture as the fourth pillar. Figure 4.1 is developed keeping this objective in mind and integrating culture with social sustainability. The framework adheres to Brundtland's concept of sustainability and further simplifies the framework for easy application.

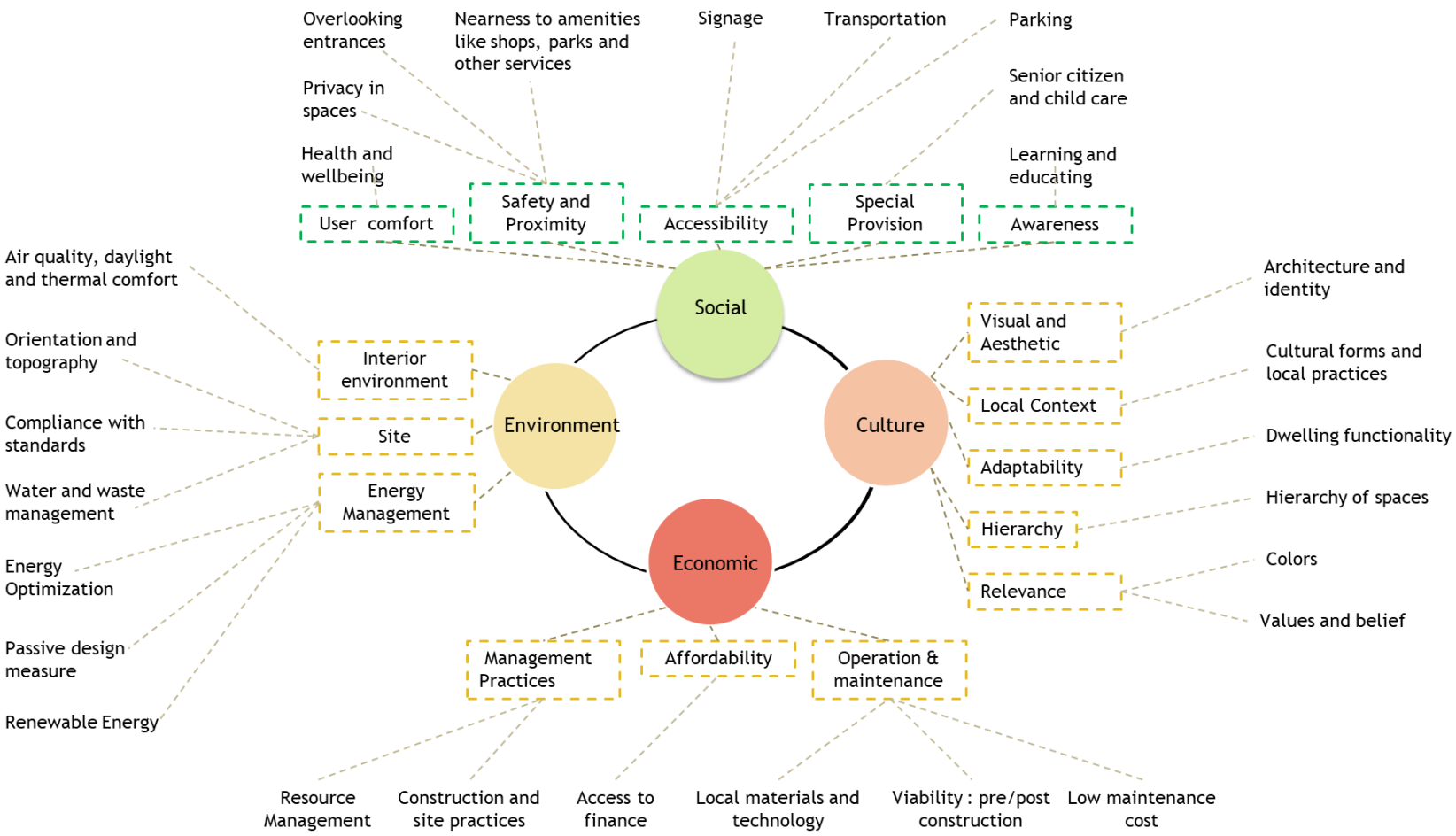

Figure 4.1: Sustainable Design Assessment Framework

4.1.3. Refinement of the framework

The framework will be further translated into a holistic design assessment system for sustainable housing. It will also help deliver enhanced regional and area-driven sustainable developments in similar backgrounds. The framework is revised again to align the concept with the Brundtland report and is summarized into three major categories: environment, economic and social.

Figure 4.2 Revised Framework for Sustainable Design Assessment

4.1.4. Chapter Conclusion

This research seeks to create a holistic approach to sustainable development by suggesting a more balanced framework. The framework is based on tangible and intangible indicators established based on primary research findings and supported by existing literature. Studies found that most of the existing sustainability frameworks, assessment tools, and guides did not adequately consider social and cultural aspects and user needs.

To examine users' and residents' perceptions and suggest indications for a holistic, sustainable strategy, this study interviewed people currently residing in India and collected data from them with the survey. It was also discovered that most frameworks for evaluating the sustainability of the built environment strongly emphasize economic and environmental factors. Due to their subjective nature, social and cultural indicators are rarely included in assessment methods. Due to their elusiveness and complexity, socio-cultural parameters were not understood. This work fills this void by suggesting intangible social and cultural elements which can be efficiently and successfully included in existing green building assessment tools, guidelines, and standards. As a result, it provides a substantial theoretical and practical contribution.

The paper outlines the participants' discussions of translating socio-cultural markers into environmental and physical parameters. The findings will be tested and validated when the framework is further translated into the tool. The process will translate intangible factors into quantifiable criteria, which can later be applied to any Indian green building system or used by experts in design and planning. The study can be concluded with the following takeaways points:

- It has been noted that residents' feedback might be more effectively incorporated into existing assessment techniques with a positive impact on satisfaction. In a scenario regarding waste management, it is assumed that the residents' needs and requirements are considered to reduce the waste of building materials due to alterations and renovations. Considering this, the resident will be cautious in using the material and management, and it could help increase residential project sustainability through awareness, cost-cutting and optimum use of supplies.

- The study demonstrates that occupants consider a socio-cultural-based design approach on a coherent knowledge of interconnected indicators which emphasize a residential home's significance and confirm user involvement's value in the design process.
- The research fills in knowledge gaps by demonstrating how intangible socio-cultural indicators and tangible design standards relate and how they can be incorporated into frameworks for evaluating sustainable buildings.
- The study deals with concerns that aid the academic and practical implementation of sustainable design assessment in understanding and reflecting on socio-cultural indicators. The learning illustrates that sustainable housing includes and focuses on the socio-cultural values of its residents.
- It supports identifying, evaluating, and incorporating sustainability indicators relating to socio-cultural sustainability into the building evaluation process.
- Residents can participate in developing sustainability goals and selecting the primary metrics and indicators used for evaluation.

Scholars, researchers, and professionals can use the study to develop similar frameworks for different contexts. Also, it can be used as a foundation for developing a tool or translating the framework into any suitable application format. In future studies, the sample size can be increased to include more residents nationwide to achieve diversified results and for the data to be more reliable and valid. Ethnographic research can be carried out to get more in-depth insights. This study combines a set of tangible and intangible indicators, providing value to the built environment’s sustainability requirement. The analysis can be utilized to recommend a new sustainability approach for housing, a roadmap for a holistic approach, and a set of indicators. These indicators can form an assessment method for new housing development projects. In similar circumstances, it can also promote regional and socio-cultural improvements. The study can be considered while developing a similar framework for other states and countries.

4.2.Sustainable Design Assessment Tool

4.2.1. Defining The Assessment Tool

The detailed literature study, survey, and integrating process described in the earlier chapter were crucial in bringing the tool's categories into focus, providing references and a theoretical framework for its content and intended usage. In addition to enhancing the sociocultural aspects of assessment methods, the in-depth review aided in generating solutions and building a library of existing best practices and solutions, thus saving time and effort. The tool intends to provide a holistic sustainable assessment for housing, thus balancing the foundation of sustainable design.

4.2.2. Adoption And Translation Of Framework

The tool development process has two significant steps: Step one is further divided into two: formulation of a framework balanced with social, economic, and environmental indicators, determined by extensive literature review and fieldwork. The second part is focused on articulating a template to structure the tool contents and the formation of categories.

Step two involves three interrelated phases: translating the sections into mandatory headings, reviewing multiple guidelines and norms with standard best practices in developed and developing countries, and incorporating them with best practices and codes designed for India.

Step three and four involve proposing a tool and its validation. Figure 4.3 explains the adoption and translation process in detail.

4.2.3. Structuring And Benchmarking Of Tool

To design the tool, five important elements were considered: introduction to the indicator and its compliance, the criteria for assessment, supporting documents for references like standard codes or policies, performance evaluation criteria, and the final score. Figure 4.2.2.1 displays a template structure designed for the tool. The template is structured in Microsoft Excel based on how the comprehensive information should be displayed. The idea behind the template is to create a simple and clean yet candid model where data is distributed section-wise, and all details can be provided.

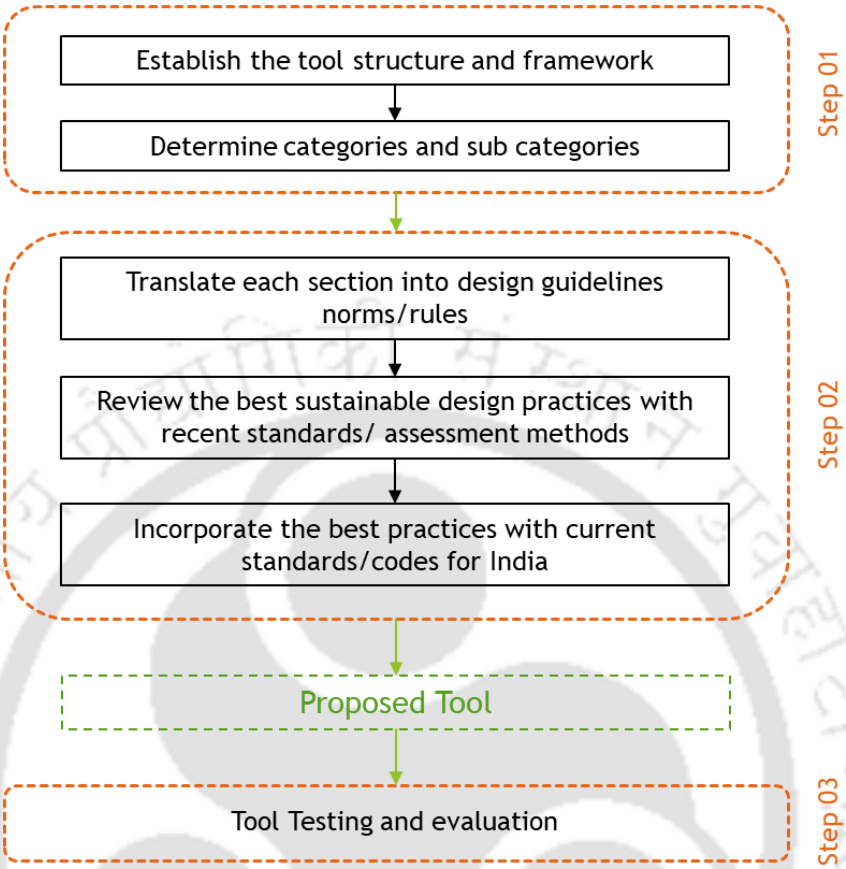

Figure 4.3 Adoption And Translation Process

For reflection of best practice approach and design standards for sustainable design, the following criteria are considered:

1. A substantial weightage is provided for their importance in the source.
2. They are related and appropriate to the scope of the sustainable design indicators.
3. Alternative practices are cross-checked between studies, as multiple terminologies and expressions are discussed related to the same sustainable design indicator.
4. The selected best practices are refined based on their application and the tool's scope for a balanced, sustainable design approach.They are moderately or not fully covered by the Indian green building rating system.

5. The scoring system for the entire tool and every section is on a scale-based system, denoting "negative" to "Best Practice" with values (-1, 0,3,5). All criteria within each category have been assigned equal weightage (i.e., 3 for good practice) except for innovation which is 1. Each score type is color-coded: red, yellow, light green, and green. The color green denotes the best possible practice and must continue with it; light green-shows good practice, yellow shows minimum requirements fulfilled, and red shows the significant need for improvement. The proposed scale is adopted as shown in the SB tool framework and guide (iiSBE,2007), and which is also mentioned in studies by Laustsen and Lorenzen (2003) and Cole and Larsson (2002).

The score of the individual section is calculated and reported after each sub-category's data, and calculations for the overall category are at the bottom of the worksheet. The last tab, "Result," provides a concise summary of all the data, divided by category and multiple graphical charts.

4.2.4. Development Of Tool

This tool intents to help assess the sustainability performance, w.r.t. environmental, social, and economic aspects of housing. The assessment tool represents key issues identified and validated through a survey that bridges the gap and creates a holistic framework for sustainable design assessment.The proposed solution and design guidelines are the outcomes of intense research, survey, and analysis. This tool might not cater to all the probable solutions and outcomes, but it has attempted to fill the void in green building rating systems and comes second to it.

The tool covers seven categories of effect, identified as the most significant potential to lessen a building’s environmental impact and eliminate the frequently met problems and barriers in a balanced, sustainable design. The categories are defined with the help of existing tools components and standard terminologies.

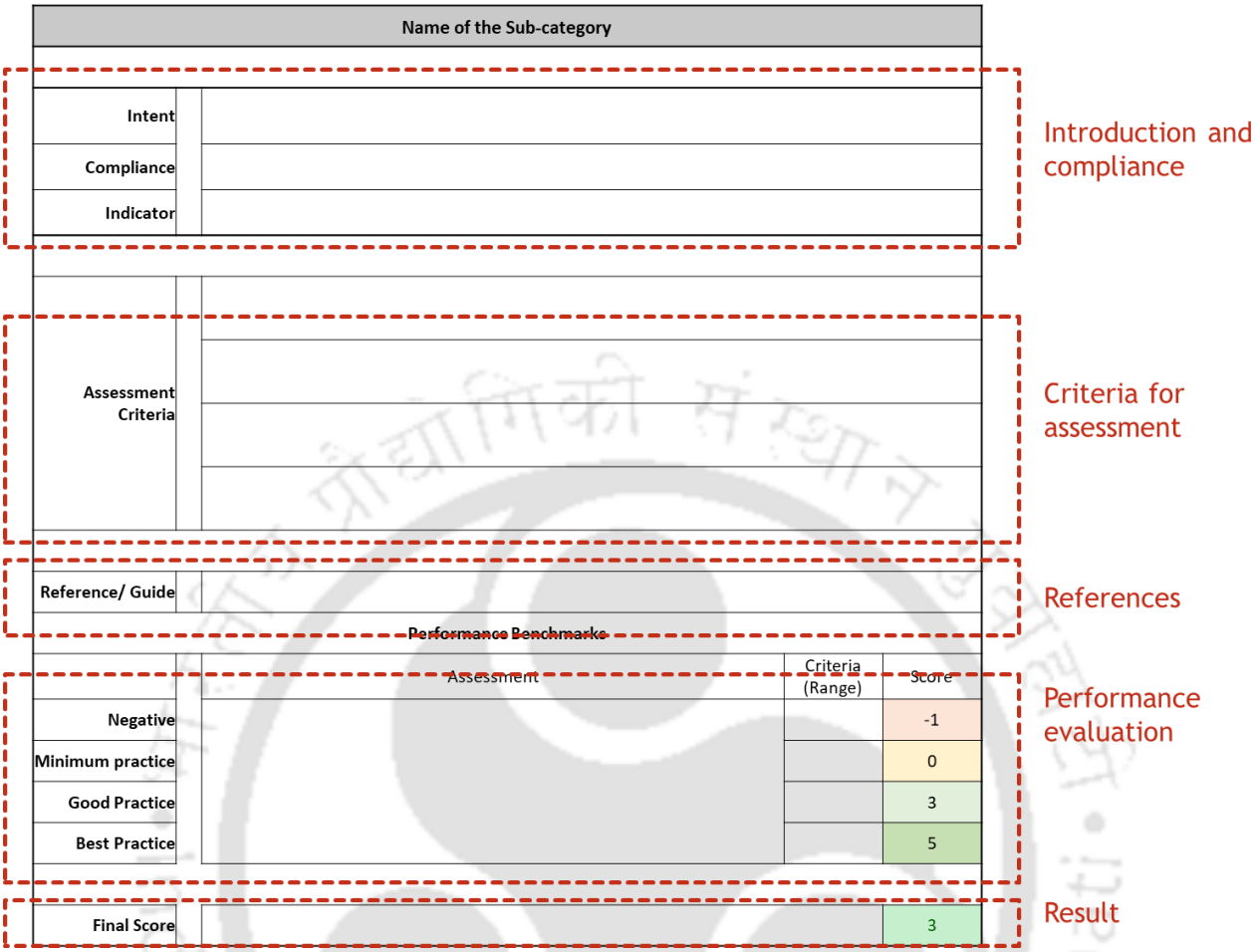

Figure 4.4 Tool Template Structure For DASH

Each of the seven categories is divided into multiple subsections for an in-depth approach to cater to the need. For each subsection, numerous sections cover the intent and assessment criteria is measured to fulfill this category's requirement. Other areas include the analysis method, compliance, reference sources, and other required criteria for evaluation and results. The existing green building rating systems inspire the seven defined categories selected in the tool, and all the indicators were determined in previous chapters. Each category chosen is divided into multiple sub-sections which define it.

Site Planning and Sustainability	Water and Waste Management	Social Co-relations	Cultural and Perceptual	Energy and Resource Management	Health and Wellbeing	Innovation

Figure 4.5 Categories Formation For Tool

4.2.5. Tool description and user guide

A user guide was provided with the tool to understand how the tool functions. It contains instructions for accessing the tool and obtaining the optimum result.

For each subcategory, i.e., "Natural Topography and Vegetation, under the "Site Planning and Neighborhood" tab:

1. To read the intent and objectives.
2. To read and comprehend the scaling and criteria, opted to measure this sub-category's success or failure.
3. Understand the assessment criteria and performance benchmarks to be followed.
4. You may evaluate the design using the assessment criteria by choosing the option from the drop-down at the “assigned score“ that fits best to you. The score and total score will display at the end of every subcategory.
5. The final sheet, " results," will present your score for all categories together.
6. For reference, a demo value and total score value have been assigned in all categories and sub-categories. You can see the final analysis in the result section.
7. Each score type is color-coded: red, yellow, light green, and green. The color green denotes the best possible practice and must continue with it; light green- shows good practice, yellow shows minimum requirements fulfilled, and red shows the significant need for improvement.

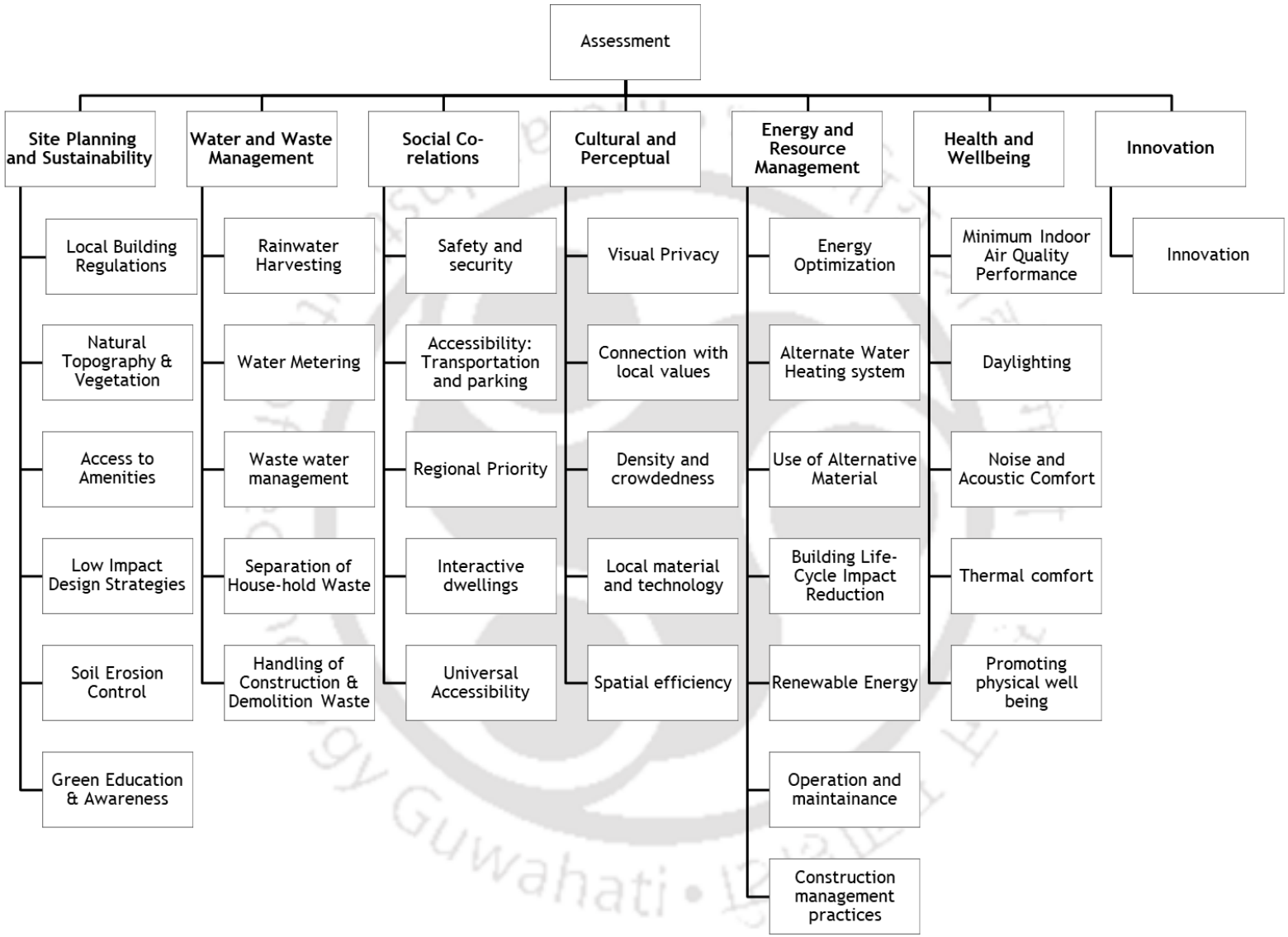

Figure 4.6 Categories and sub categories for tool development

8. The user must repeat the process until all sections are answered.

9. The user must review the steps for each category from 1 to 7.

10. If the user wishes to use and test the tool for personal projects, you can ask for an editable file.

11. The complete version of the tool is attached in the annexure section. Kindly refer to the tool there. Also, the tool can be referred online with the link: DASH_Tool_V2.xlsx. And DASH TOOL_ V2_PDF.pdf.

4.3.DASH : Testing And Validation

4.3.1. Tool Validation : Process

To authenticate and validate the tool, an in-depth review was requested by a few industry experts from a similar field to analyze the tool and give their unbiased feedback. The tool was shared in an open Microsoft Excel file with the experts half a month before the interview. The idea is to get the industry expert familiar with the tool. The feedback process was later followed with an in-depth discussion over the phone call and filling out the feedback form. The interview is scheduled over phone calls, lasting approximately 45-60 mins. The feedback form was shared after the call to rate the tool's efficiency and effectiveness.

4.3.2. View Of The Practitioners

Seven respondents agreed to participate in the tool validation process. Of these seven experts, three respondents are subject matter experts, three are consultants or advisors, and one is a technical advisor from their respective field. Figure 4.3.2.1 displays the information regarding the current role of respondents in their respective organizations.

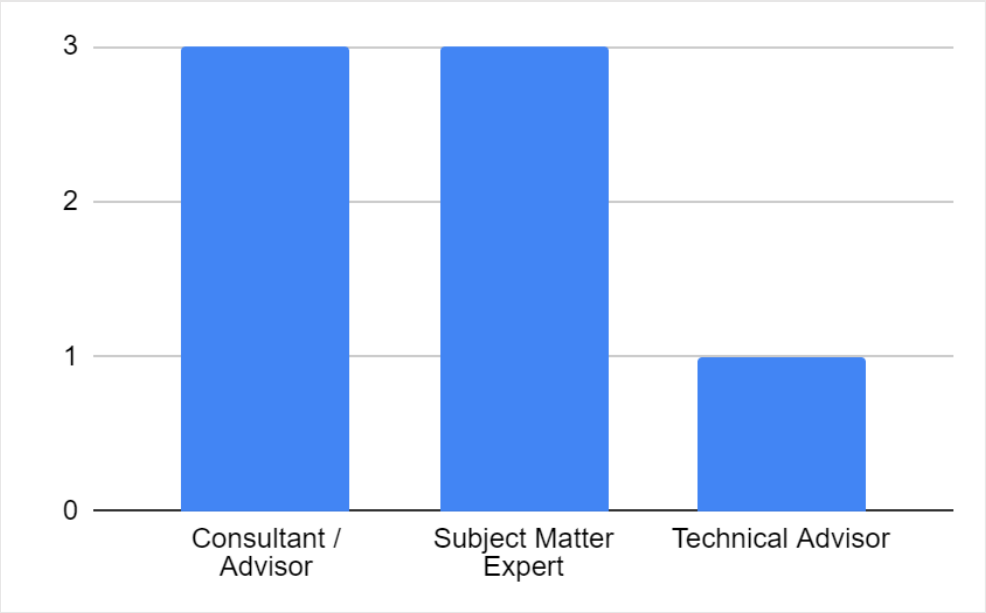

Figure 4.7 Current Role Of The Respondents For Tool Validation

In terms of the total years of experience of the respondents, three have experience of more than 20 years, two of them have experience of 10-14 years, and the other two have experience of 5-9 years in their respective fields. Figure 4.3.2.2 displays the information regarding the total years of experience they have.

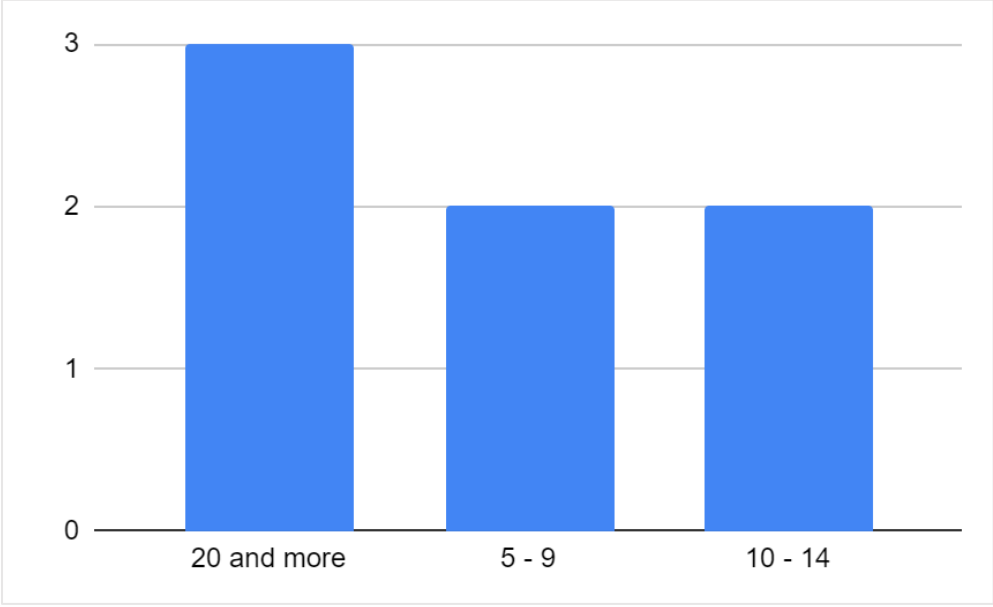

Figure 4.8 Years of experience of the respondents for tool validation

Regarding the respondents' educational qualifications, two respondents hold a PH.D. degree, and the rest five have a master's degree. Figure 4.3.2.3 displays the information regarding the educational qualification of respondents.

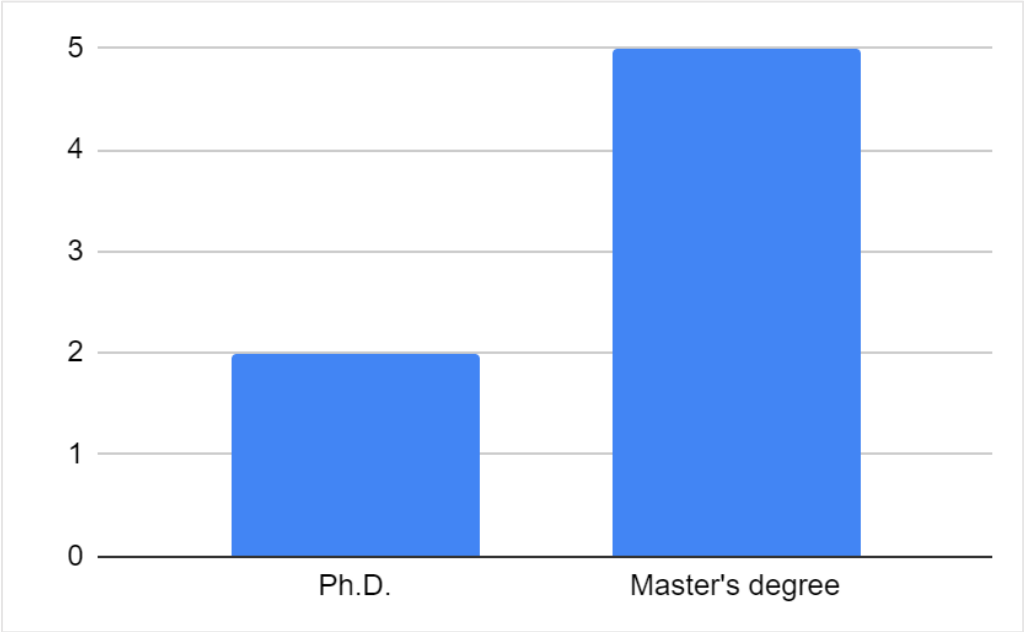

Figure 4.9 Educational Qualification of the Respondents for tool validation

The respondent's details shall be kept anonymous. The professional information of these respondents will be mentioned in the following manner. The first respondent will be P01, currently working as the head of the organization in PS Collective and holding a Ph.D. degree with an experience of 20 and more years. The second respondent will be P02, currently working as a consultant in the Centre for Research and Sustainable Development and holding a Ph.D. degree with an experience of 20-plus years. The third respondent will be P03, currently working as a subject matter expert at International Institute for Energy Conservation and holding a master's degree with an experience of 5-9 years. The fourth respondent will be P04, currently working as Subject Matter Expert in Tata Sons and holding a master's degree with an experience of 5-9 years. The fifth respondent will be P05, currently working as the Technical Advisor in Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and holds a master's degree with an experience of 10-14 years. The sixth respondent will be identified as P06, currently working as the Subject Matter Expert in Renew power and holding a master's degree with an experience of 20

plus years. The seventh respondent will be P07, currently working as a senior consultant in Green Business Certification Inc. (GBCI) and holding a master's degree with an experience of 10-14 years.

4.3.3. Reflection On The Feedback

In the tool validation process, the respondents are further asked to fill out a feedback form after reviewing the tool and having discussions over phone calls. The feedback form is divided into four parts, involving questions about their professional details, effectiveness and accuracy of the tool, efficiency and utility, and open-ended feedback and suggestions.

In evaluating the effectiveness and accuracy of the tool, the data concludes an agreement of over 77% among all categories. Figure 4.3.3.1 displays the information regarding the distribution of responses on the effectiveness and accuracy of the tool. Figure 4.3.3.2 shows information regarding the average mean score on the effectiveness and accuracy of the tool, and the scores range between 3.9 – 4.3 for all statements.

When evaluating the effectiveness and accuracy part of the tool, it is safe to conclude that there is an agreement of over 74% among all categories. Figure 4.3.3.3 displays the information regarding the distribution of responses on the efficiency and utility of the tool. Figure 4.3.3.4 shows the tool's average mean score on efficiency and utility, and the scores range between 3.7 – 4.4 for all statements.

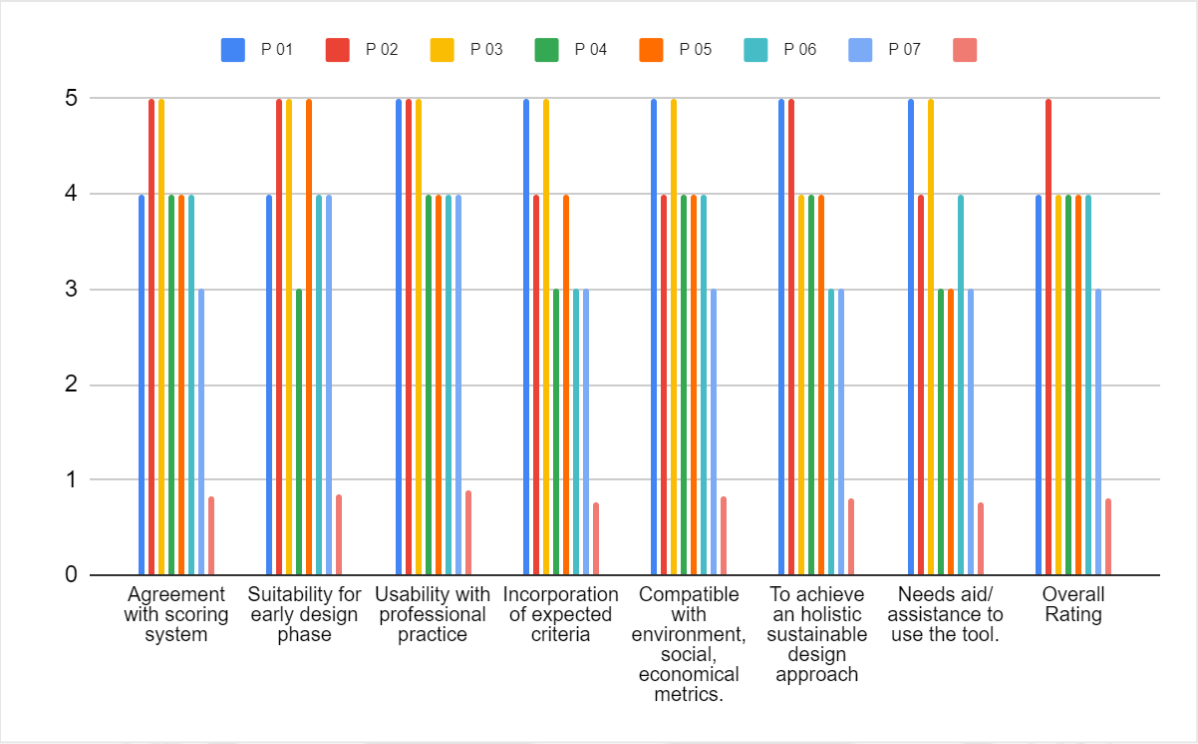

Figure 4.10 Distribution Of Responses On Effectiveness And Accuracy Of The Tool

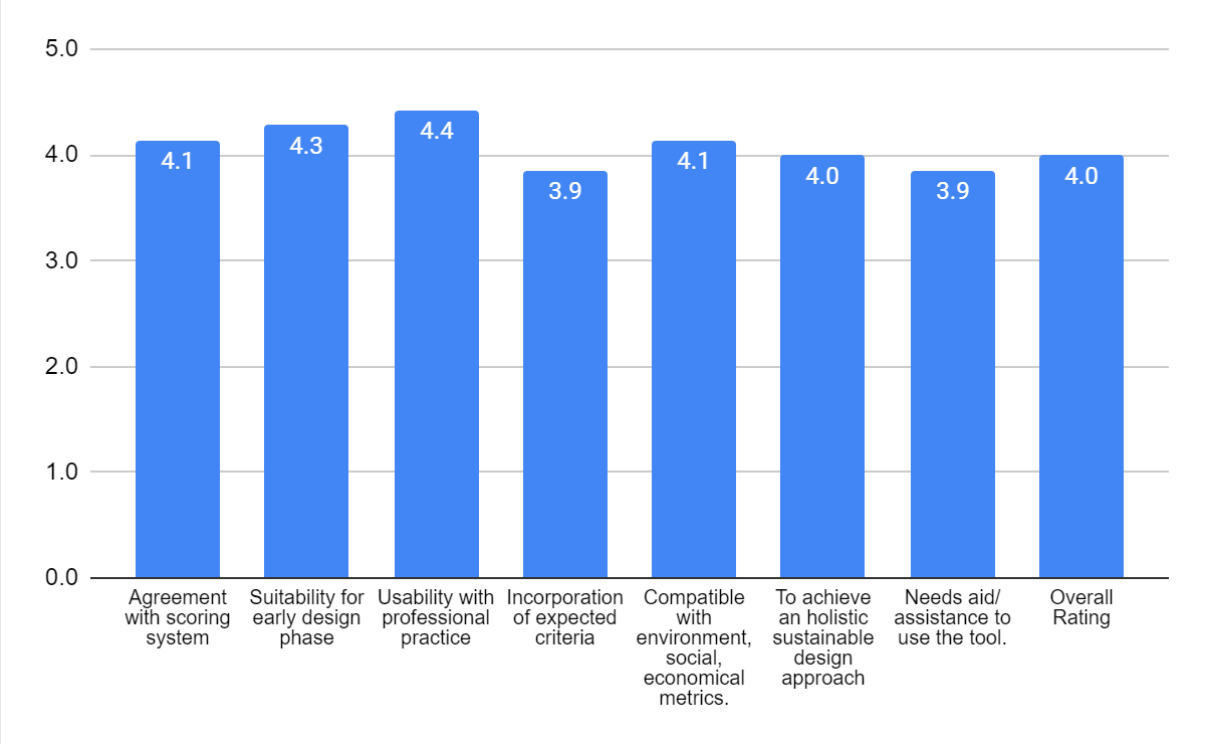

Figure 4.11 Average Mean Score On Effectiveness And Accuracy Of The Tool

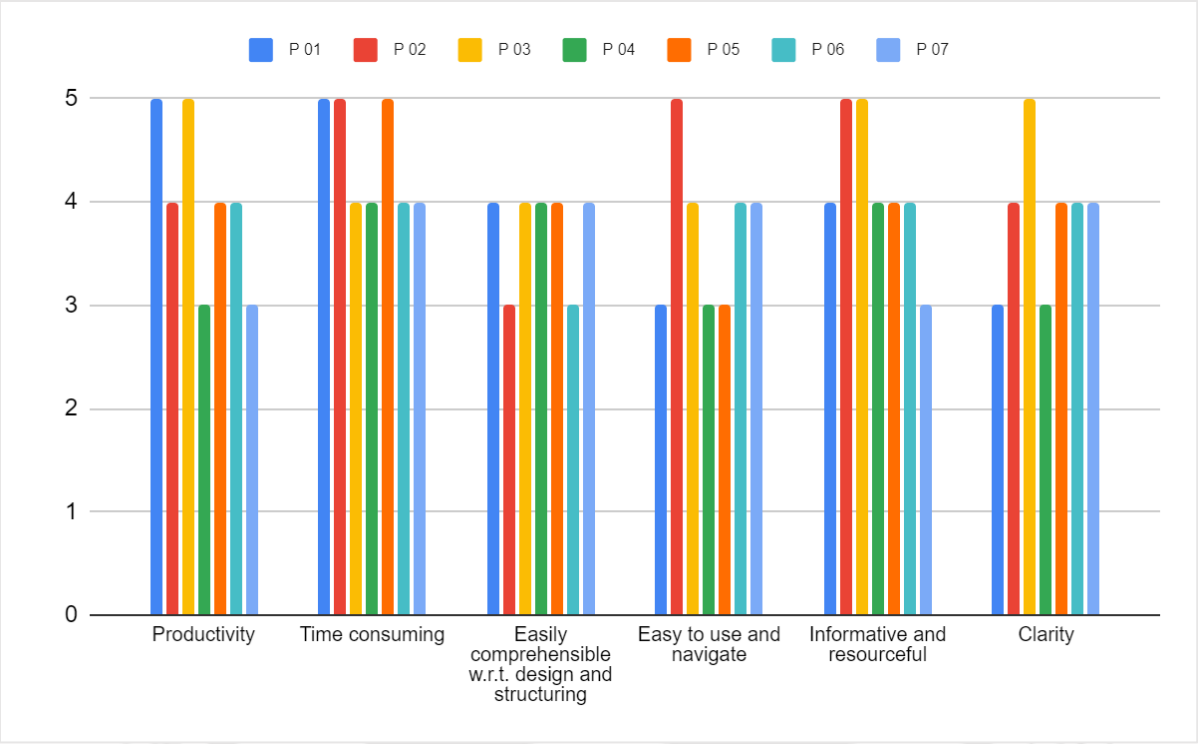

Figure 4.12 Distribution Of Responses On Efficiency And Utility Of The Tool

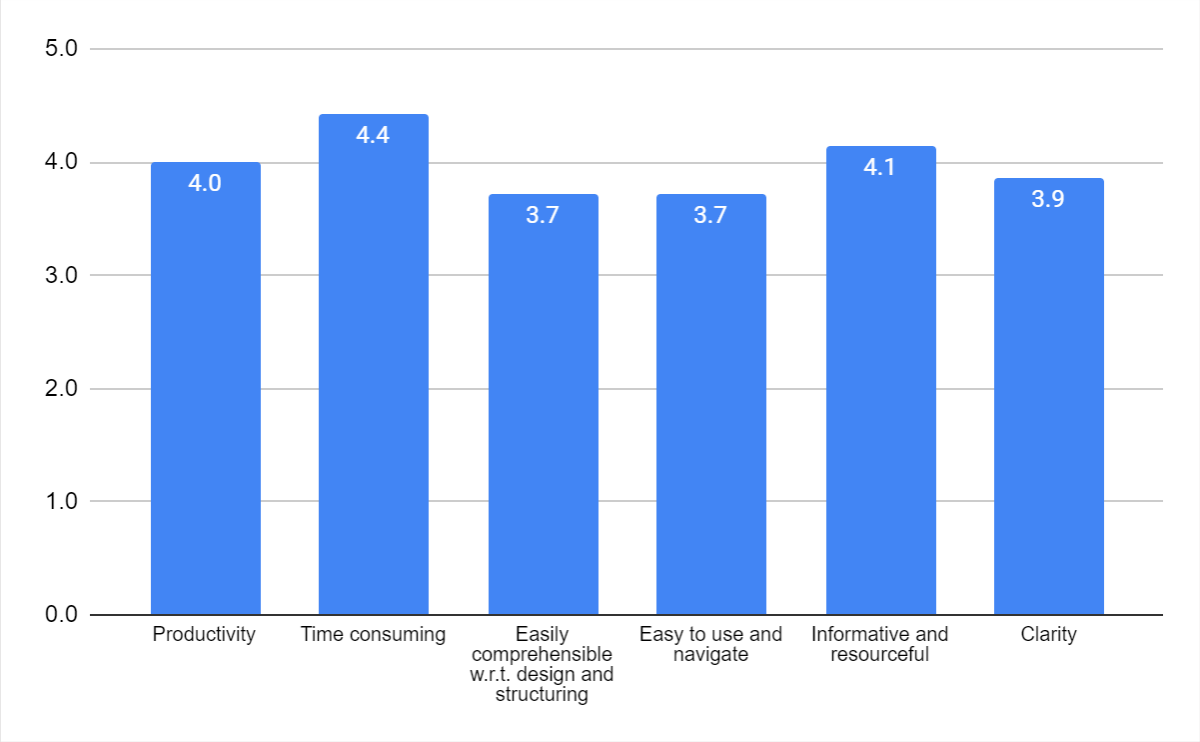

Figure 4.13 Average Mean Score On Efficiency And Utility Of The Tool

4.3.4. Feedback Of The Respondents

After completing the tool's testing, participants were given a set of five general questions to answer about it, including: What is lacking? What elements are not necessary? What areas are complicated? Is there an additional discrepancy or difficulty that needs to be catered to? What are the strong and weak points? The questionnaire's findings are used to support conclusions drawn from the respondent analysis. The results of each study are displayed in the sections below. Each of the seven participants has a diverse background. Thus, each used the tool independently and had different expectations for what it would accomplish. However, the challenges they ran against and the surfaced topics were somehow related. As a result, comments that were similar to one another or belonged to the same subcategory were grouped. In the following subsections, these are addressed.

- Missing/ Unwanted Elements

Participant P01 commented:

“The criteria points section in the performance benchmark system could be misleading and confusing. It often shows repetitive information, as mentioned in the assessment section. “

Participant P02 commented:

“In TGD 03 section, under accessibility: transportation facility: Availability of Non-motorized transport facility like cycle tracks can be added. Second is Road safety infrastructure availability to ensure safety improvement on-road standards.”

Participant P03 commented:

“There can be a numbering system/header for all criteria and categories like 1,1.1,1.2, etc. Navigating and knowing where we are on each section will be easier. “

Participant P05 commented:

“Before planning a site, one must assess if built space should come up in that land. Whether it is safe to construct the house (not low-lying and non-hazardous land) if it is in an eco-sensitive area.”

Participant P07 commented:

“Social and equity aspects need to be explored more; concepts like TOD, walk score, Green cover per capita should be explored, address special waste/ hazardous waste.”

- Strengths and weakness

Participant P01 commented:

“Criteria keep changing in most cases. It is in the form of percentages and numbers. It is difficult to understand (The description is a problem). “

Participant P02 commented:

“Dislike no pictures used to make it more user friendly. “

Participant P03 commented:

“One thing that I found unique and liked about the tool is that it defines 'minimum practice' for any intent and helps realize the good and best practices for that category. This makes the user often pass by with the bare minimum. This result is probably a high score and consecutively a high ranking for sustainability ranking, but a very averagely performing building on the ground. “

Participant P04 commented:

“Good to see the tool in excel; it makes it easier to use and calculate. “

Participant P05commented:

“I liked the thorough coverage of critical aspects. “

Participant P07 commented:

“I like the information structuring and resources provided at each section, although there can be an entirely separate section.”

“Unsure if 'Crowdedness' is a correct word. Density alone seems to be fine.”

- Errors and concerns

Participant P01 commented:

“Highlight the cell where the user needs to input the data. Numbering to each category for smooth process flow. Lock cells which have a pre-defined set of values for better clarity.”

Participant P05 commented:

“Just see if the first point can be incorporated.”

Participant P07 commented:

“Spell check needs to be done. Spelling errors are there in a couple of places.”

- Other Suggestions

Participant P01 commented:

“Good to see the tool over Excel; easy to try and see results.”

Participant P02 commented:

“Try to make it more attractive or user friendly like it can be used on mobile or android platforms.”

Participant P03 commented:

“The bar graphs at the 'Results' tab could be improved. Though the numbers on the graph represent a clear picture, the visuals might be slightly misleading and confusing. The percentage representation might be more useful in this regard."

Participant P04 commented:

“May include governance criteria.”

Participant P07 commented:

“Review and add a reference to international rating systems like LEED, BREEAM, and Mostadam. These cover a lot of additional concepts than NBC.”

The following are the consideration from all the comments mentioned above:

1. Criteria are mentioned more clearly.
2. The input error scope is now reduced to zero, and a new drop-down function is introduced.
3. Headers are mentioned in each category and sub-category for better visibility.
4. The final score at each section is changed into an assigned score, and the input cell is highlighted.
5. The scores are now visible in the division and checklist section as the user fills in data.
6. A new chart is introduced in the result section to display the percentage value representation of each section.
7. An attempt is made to highlight the values in the template for each section.

4.3.5. Usability Testing: Phase I and II

Usability testing was conducted with the help of participant observation techniques. This additional validation was undertaken to enhance the tool's user experience, followed by open-ended and closed-ended questions. The testing was conducted as experiments in two phases; with a limited set of people for different groups; seperately for versions 1 and 2. The tool was gauged through heuristics principles. The study was conducted in two parts, each with three participants. The participants were asked to go through the entire tool step by step and utilize it. With each participant, the expriment lasted for 30-60 mins, where the participant was using the tool as per their understanding and every question they prompted become our scope of improvement. The

experiment involved both active and passive involvement of the researcher. Later, they were provided with a feedback form for more comments.

All observations were considered and the versions were further validated and rectified for the optimum experience. The tool is revised based on the feedback received from all industry experts. Both tool versions have been showcased in the annexure section for a clear picture.The details of heuristic evaluation can be seen in table 4.1.

4.4.Chapter Conclusion

The tool intends to provide a holistic assessment approach toward sustainable development. In recent times, there has been an inclination to research a sustainable built environment towards the significance of the social and cultural wellness of the inhabitants. There is, however, a lack of immediate consideration in the standards for green building rating systems to address this issue and improve the performance of buildings in the residents' well-being and satisfaction dimensions. Instead of the conventional optimization of energy performance, these tools focus on observed and quantitative aspects of sustainability, for example, the amount of daylight, air quality, and thermal comfort. These suggested solutions also lack detailed information and region-specific adaptation.

Results from the data collection and tool support the research's conclusions regarding the significance of socio-cultural indicators. They can establish the context in the design process and sustainable building assessment.

Table 4.1 Heuristic Evaluation

S.no	Heuristic Principles	V1	V2	Remarks
1	Visibility of system status			The system status is only visible in Tab 03, Division and Checklist, where the user can see how many sections have been accessed.
2	Match between the system and the real world			The language used is familiar to any general user. (A glossary sheet can be provided at the end for further clarification of specific terms)
3	User control and freedom			Users can control the movement and can go anywhere between the tabs. An emergency exit is not required in this case.
4	Consistency and standards			All abbreviations are explained within the section. Users might find it difficult to understand a few terminologies.
5	Error prevention			The input values are pre-defined in the system. Users must choose between the values by clicking at the drop-down function.
6	Recognition rather than recall			The headers are provided in each tab to recognize the progress.
7	Flexibility and efficiency of use			All scores are automatically calculated, and the results will be generated. Flexibility is provided in the movement from one tab to other.

8	Aesthetic and minimalist design			The design is very structured and easy to understand with a simple and easy-to-understand template. The input tab is color enhanced.
9	Help users recognize, diagnose, and recover from errors.			All cells in the sheet are protected. Users can only input data in the assigned score section. Everything will get calculated at the end automatically.
10	Help and documentation			The user guide is provided at the start for a smooth process.

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Chapter 5

CONCLUSION AND WAY FORWARD

5. CONCLUSION AND WAY FORWARD

5.1.Summary Of The Study

The study aimed to achieve four objectives. The first objective of the study **(To focus on socio-cultural sustainability: Merging culture as 4th pillar of sustainability/ as an extension to social sustainability)** was achieved primarily by establishing the context and background for research and with the help of existing literature in journal publications, reports, books, and other relevant published sources. Secondary data is reviewed through a systematic literature review on areas of sustainability and three pillars, global and Indian context on sustainable development, housing, social and cultural aspects of housing, green building rating systems in developed and developing countries, building standards and codes, housing and energy policies and related concepts. Through secondary research, it revealed that it is viable to identify, recognize and select social and cultural indicators for a sustainable built environment.

The study's second objective **(To find relevant socio-cultural indicators (tangible and intangible) that are occupants defined)** focuses on establishing and validating social and cultural indicators from occupants' perceptions. The main goal here is to prioritize the inclusion of social and cultural indicators in a sustainable built environment. The objective is achieved by identifying the key categories influencing the sustainability of residential buildings and integrating social and cultural dimensions along with the environmental and economic in building sustainability. A pilot study is conducted at the initial stages to understand the occupant's perception by conducting an in-depth interview. An open-ended comprehensive interview is conducted through the discovery-oriented method to obtain detailed information about a topic from a user and to comprehend the questionnaire's scope, the user's behavior response, and their understanding. The duration of each call/interview is approximately around 30-45 mins. After validation of the pilot run, a survey-based study was conducted. The study was conducted with limited participants from different cities in India. A total of 133 users/ residents participated in the survey. The entire data was analyzed using multiple graphs and charts. The users were also asked to rate their views on selected indicators using a five-point Likert scale. A list of tangible and intangible indicators related to existing and ideal sustainable housing scenarios was shared for this analysis. The data is analyzed using graphs, and statistical analysis has been conducted to observe significant co-relations

between identified variables. After the survey and data analysis, the study could validate the relationship between these indicators. Thus, the final list of indicators was created to be considered for the study to develop the framework.

The third objective of the study **(To propose a balanced, sustainable design assessment framework)** A theoretical framework is developed focusing on identified variables and defining the specific viewpoint formulated from the user behavior study and secondary data. A total of thirty-four indicators were considered for the final study. The developed framework showcases the indicators and interpretations of the survey in a summarized form for social, environmental, economic, and cultural indicators. This study intends to create a socio-cultural framework for housing based on a logical, rational collection of complementary physical and intangible variables. The foundation of the study is based on the concept of sustainability as suggested by the Brundtland Commission, which is based on three pillars: environment, economic and social. The study's first objective is to focus on socio-cultural sustainability: merging culture as an extension to social sustainability or considering culture as the fourth pillar. Hence, the framework is revised to keep this objective in mind and connect the cultural dimension with social sustainability. The framework adheres to Brundtland's concept of sustainability and further simplifies the framework for easy application.

The fourth objective of the study **(To translate the developed framework into an assessment tool with the help of existing green building guidelines and assessment methods)** was achieved by translating the developed framework into an assessment tool with the help of existing green building guidelines and assessment methods. Standard practices are considered the point of reference for benchmarking the study. The entire tool is designed and developed in a spreadsheet format using Microsoft Excel version 2019, and multiple standards and guidelines are reviewed to establish a valid context. The navigation, ease of use, and content are simplified using formulas and function control. Consistency and standard protocol have been maintained throughout for easiness and reduction of error. Industry experts validated the tool, and an additional validation was conducted to enhance the tool's user experience. The testing was conducted in two phases for different groups; thus, versions 1 and 2 were developed, respectively.

5.2.Summary Of The Contribution

The contribution from the research is as follows:

- It demonstrates that housing residents consider socio-cultural design based on a coherent knowledge of interconnected indicators that emphasize a residential home's significance and confirm user involvement's value in the design process.
- The research fills in knowledge gaps by demonstrating how intangible socio-cultural indicators and tangible design standards relate and how they can be incorporated into frameworks for evaluating sustainable buildings.
- The study deals with concerns that aid both academic and practical implementation of sustainable design assessment in understanding and reflecting socio-cultural indicators and developing a toolkit with current architectural practices.
- This study illustrates that sustainable housing includes the socio-cultural values of its residents.
- It supports identifying, evaluating, and incorporating sustainability indicators relating to socio-cultural sustainability into the building evaluation process.
- Using a sustainable design assessment tool encourages the incorporation of relevant socio-cultural design criteria and the implementation of adjustments to enable a more holistic sustainable design and green building.
- Occupants and residents can participate in developing sustainability goals and selecting the primary metrics and indicators used for evaluation.

5.3.Limitations And Future Scope

The limitations of the research are as follows:

- The secondary data reviewed in the study deals with peer-reviewed publications and publicly accessed reports, codes, and standards, which combine both practical and academic knowledge. A broader context could be covered if other frameworks (apart from rating systems) from around the globe have been analyzed.
- The survey study is conducted with a limited data set due to restrictions during Covid-19. The fieldwork can be conducted in-depth in the future, which caters to a more diversified audience to reveal more indicators and dimensions that this research might have missed.
- Regarding the framework and tool development, the core focus is on the indicators w.r.t. environment, economic, social, and cultural dimensions. The benchmarking standards of the developed tool, like scaling, scoring, and other assessment criteria, are adopted for existing tools.
- Industry professionals or users can only utilize the developed tool with prior knowledge of technical terminology of green buildings and related concepts. Third-party support will be required for any resident/occupant who wish to access the building.
- Toolkit efficacy can be evaluated further by assessing it with a few pilot projects and gauging the user's satisfaction compared to existing tools.

The future scope of the research is as follows:

- To develop the tool into a graphical interface like an application, web page, or plug-in, which could be easily installed and utilized with an existing built app/software while developing and accessing a design in any development phase: designing and pre-construction, during and post-construction.
- A handbook could be developed enlisting multiple building methods, local materials, and technologies inspired by different regions to encourage the use of regional settings and create a transition to a low-carbon future.

- Building guidelines can be challenging to comprehend for residents. Hence faster finding and informal execution methods are required to ease the administration of a green building rating system.
- Integrating sustainable design practice with architectural design and construction will help influence design and practices based on more social and cultural approaches.
- Educating and raising awareness regarding sustainability amongst all stakeholders like occupants, homeowners, professionals, and officials by encouraging their participation in decision-making and related developments.

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5.4.List Of Publications

1. Piparsania, K., & Kalita, P. C. (2022). Development of DASH: Design Assessment Framework for Sustainable Housing. Sustainability 2022, Vol. 14, Page 15990, 14(23), 15990. https://doi.org/10.3390/SU142315990.
2. Piparsania, K., Kalita, P. (2023). Overview of Multi-Stakeholder Approaches and Initiatives for Achieving Sustainable Development in the Residential Sector. In: Chakrabarti, A., Suwas, S., Arora, M. (eds) Industry 4.0 and Advanced Manufacturing. Lecture Notes in Mechanical Engineering. Springer, Singapore. https://doi.org/10.1007/978-981-19-0561-2_30.
3. Piparsania, K., Kalita, P. (2022). Insights on Green Building Rating Systems for Housing in India and Their Assessment with Pillars of Sustainability. In: Bruyns, G., Wei, H. (eds) [ ] With Design: Reinventing Design Modes. IASDR 2021. Springer, Singapore. https://doi.org/10.1007/978-981-19-4472-7_159.
4. Piparsania, K., & Kalita, P. C. (2021, December). Interpreting social and cultural sustainability for housing. In VIII Simpósio de Design Sustentável/Symposium on Sustainable Design.https://doi.org/10.5380/8sds2021.art21.
5. Lomba M., Lubis P.Y., Poçan G., Amankwah A.M., Piparsania K., Xia N. (2021, December). Ph.D. Student Forum: Ongoing doctoral research on Design for Sustainability. In VIII Simpósio de Design Sustentável/Symposium on Sustainable Design. https://doi.org/10.5380/8sds2021.art72.
6. Piparsania, K., Kalita, P.C. (2021). Review of Building Energy Code and Its Implementation in Residential Sector: A Global Outlook. In: Chakrabarti, A., Poovaiah, R., Bokil, P., Kant, V. (eds) Design for Tomorrow—Volume 1. ICoRD 2021. Smart Innovation, Systems and Technologies, vol 221. Springer, Singapore. https://doi.org/10.1007/978-981-16-0041-8_77.
7. Piparsania, K. R., Vaidya, P., & Kalita, P. C. (2020). Evaluation of daylight performance of classroom spaces in Ahmedabad. DS 101: Proceedings of NordDesign 2020, Lyngby, Denmark, 12th-14th August 2020, 1-12. https://doi.org/10.35199/NORDDESIGN2020.29.

In Process:

- Piparsania, K., Kalita, P.C. (2022). Overview of sustainability assessment methods and evaluation tools for the residential sector. North East Research Conclave 2022.Springer, Singapore. (Selected, to be published).
- Piparsania, K., Kalita, P. (2022). Sustainable design assessment tool for housing. Sustainability,14(XX), XXXXX. (Under review).

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Chapter 6

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Chapter 7

ANNEXURE

ANNEXURE A & B

QUESTIONNAIRE

7. ANNEXURE

7.1. Annexure A: Pilot study questionnaire

Aim of the study: The study is focused on finding socio-cultural indicators for sustainable housing. The purpose of the study is to collect demographic data, details regarding the existing household, and the occupant's perception regarding sustainability indicators.

Criteria to participate: The study must represent a broader range of cases to provide insights; all occupants should be residents of India, aged 18 and above, irrespective of gender, engagement, or financial background. The data collected with this questionnaire will only be used for academic purposes.

If the occupant is willing to provide more insightful information through discussion, you may mention your contact details at the end of the form. Thank you for your contribution.

- Email
- Name
- The current city of residence
- Gender
    - Male
    - Female
    - Prefer not to say
- Age range
    - 18-30
    - 31-40
    - 41-50
    - 51-65
- Type of Ownership
    - Owned
    - Rented
- Building age/ year of construction (without renovation)
- Type of house
    - Apartment / Flat
    - Row House / Bungalow
    - Detached / Semi Detached
    - Other

- Built-Up area of the house (in square feet)
    - 0-1000
    - 1000-2000
    - 2000-3000
    - 3000-4000
    - 4000- above
- Family Members

Aged between 0-18 years	**0**	**1**	**2**	**3**
Aged between 18 - 60 years				
Aged 60 years and above				

- Occupation
- Income group
    - Low
    - Medium
    - High
- House Details

Living Room	**1**	**2**	**3**	**3**
Bed Room				
Bathroom				

- Have you renovated or made any changes in the house ?
    - Yes
    - No
- If yes, then, please select the required option.
    - Entire House
    - Walls (Wall thickness/ Cladding)
    - Windows (Change of the framing material or glass)
    - Ceiling (False ceiling or for insulation)
    - Balcony (Covered for extending room or other purposes)
    - Other:
- Do you have the leverage to add spaces to exterior?
    - Yes
    - Other:
    - No

- Did you make any additions in the house for kids or senior citizens?
    - Yes
    - No
    - Other:
- What material have you used in the outer wall of the house?
    - Plaster with brick wall
    - Tiles on the brick wall
    - Stone on the brick wall
    - Other
- Do you have any of the following elements in your house? (you can select more than one option)
    - Courtyard
    - Garden
    - Tulsi court
    - Verandah
    - Other
- What do you feel about your neighborhood?
    - Congested and crowded
    - Calm and peaceful
- Please rate the following statements on a scale from 1 - 5, with 1 being the lowest and 5 being the highest.
    - The ratio of public and private spaces
    - Area allocation of each room
    - Level of satisfaction within the building
    - Experience with neighborhood
    - Material quality and durability
- Do you have any social interaction spaces within/nearby your house?
    - Yes
    - No
- If yes then, please select the space
    - Garden / Park
    - Walking path
    - Open activity space
    - Semi Shaded/ shaded spaces
    - other
- Do you have any green space within your house?
    - Yes
    - No
- Do you face any challenge/discomfort in everyday life within your spaces?
    - Yes
    - No

- Please rate the following statements on a scale from 1 - 5, with 1 being the lowest and 5 being the highest.
    - One must use locally available materials during construction
    - There must be continuity in building style for a community
    - One must have visual privacy at the main entrance of the house
    - One should maintain a hierarchy of spaces for guests and family
    - One must have the flexibility to customize the house
    - Interactive spaces within the house (living & dining)
    - Access to outdoor spaces and parks
    - Common meeting areas within premises (courtyard/ veranda)
    - Reflection of cultural values and Beliefs
    - Architectural connection with local Identity
    - Ease of accessibility within spaces
    - Main road connectivity
    - Overall low maintenance
    - Provision for safety and security
    - Ample daylight through all seasons
    - Low Noise Transmission from nearby homes
    - Provision for rainwater harvesting
    - Natural ventilation during various seasons
    - Use of energy-efficient appliances
    - Sharing ideas about sustainability
- Please upload pictures of your house (preferably: from outside, living, kitchen, dining and other rooms)
- If you want to specify any other detail, kindly mention it here. If you are willing to provide the same through in-depth discussions, kindly mention your contact details

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7.2. Annexure B: Data collection user guide

Aim of the study: The study is focused on finding socio-cultural indicators for sustainable housing. The purpose of the study is to collect demographic data, details regarding the existing household and the occupant's perception regarding sustainability indicators.

Criteria to participate: The study must represent a broader range of cases to provide insights, all occupants should be residents of India, aged 18 and above, irrespective of gender, engagement or financial background. The data collected with this questionnaire will only be used for academic purposes.

If, the occupant is willing to provide more insightful information through discussion, you may mention your contact details at the end the form. Thank you for your contribution.

- Email
- Name
- Current city of residence
- Gender
    - Male
    - Female
    - Prefer not to say
- Age range
    - 18-30
    - 31-40
    - 41-50
    - 51-65
- Type of ownership
    - Owned
    - Rented
- Age of the building: without renovation. (only mention the number. E.g.: 24)
- Type of house
    - Apartment / Flat
    - Row House / Bungalow
    - Detached / Semi Detached
    - Other
- Built- Up area of the house (in square feet)
    - 0-1000
    - 1000-2000

- 2000-3000
- 3000-4000
- 4000- above
- Other

- Family Members

Aged between 0-18 years	**0**	**1**	**2**	**3**	**4**	**5**
Aged between 18 - 60 years						
Aged 60 years and above						

- Occupation
- Income group
  - Lower
  - Lower-Middle
  - Middle
  - Upper-Middle
  - High
- House Details

Living Room	**1**	**2**	**3**	**4**	**5**
Bed Room					
Bathroom					

- Renovated or made any changes in the house*
  - Yes
  - No
- If yes, then please select the required option.
  - Entire House
  - Walls (Wall thickness/ Cladding)
  - Windows (Change of the framing material or glass)
  - Ceiling (False ceiling or for insulation)
  - Balcony (Covered for extending a room or other purpose)
  - Other:
- Do you have the leverage to add spaces to the exterior?
  - Yes
  - Other:
  - No
- Did you make any additions to the house for kids or senior citizens?

- Yes
- No
- Other:

- What material have you used in the outer wall of the house?
  - Plaster with brick wall
  - Tiles on the brick wall
  - Stone on the brick wall
  - Other
- Do you have any of the following elements in your house? (you can select more than one option)
  - Courtyard
  - Garden / Terrace garden / Area for potted plants
  - Tulsi court
  - Verandah
  - Pooja Room/ Mandir
  - Other
- What do you feel about your vicinity (adjacent neighborhood)?
  - Congested and crowded
  - Calm and peaceful
- Please rate the following statements on a scale from 1 - 5, with 1 being lowest and being the highest.
  - Ratio of public and private spaces
  - Area allocation of each room
  - Level of satisfaction within the building
  - Experience with neighborhood
  - Material quality and durability
- Do you have any social interaction spaces within/nearby your house?
  - Yes
  - No
- If yes then, please select the space
  - Garden / Park
  - Walking path
  - Open activity space
  - Semi Shaded/ shaded spaces
  - other
- Do you have any provision of an emergency exit within your house/society?
  - Yes
  - No
  - Other

- Do you face any challenge/discomfort in everyday life within your spaces?
    - Yes
    - No
    - Other
- Please rate the following statements on a scale from 1 - 5, with 1 being the lowest and 5 being the highest.
    - Use of locally available materials and technology during construction
    - Continuity in building style for a community
    - Visual privacy in principal areas of the house
    - Maintaining a hierarchy of spaces
    - Flexibility to customize/renovate the house
    - Abide by compliance
    - Common meeting areas or interactive spaces within the premises
    - Reflection of cultural values and Beliefs
    - Architectural connection with local Identity
    - Ease of accessibility to spaces
    - Special Provision for senior citizens/child care/ differently abled.
    - Less operational and maintenance cost
    - Provision for safety and security
    - Ample daylight and ventilation
    - Low Noise Transmission
    - Provision for rainwater harvesting
    - Affordable management practices
    - Provision to add a renewable energy source/ passive design measure
    - Sharing ideas about sustainability
    - Proximity to local services and transportation
- Please upload pictures of your house (preferably: from outside, living, kitchen, dining, and other rooms)
- If you want to specify any other detail, kindly mention it here. If you are willing to provide the same through in-depth discussions, kindly mention your contact details.

ANNEXURE

TOOL VALIDATION

7.3. Annexure C: Tool Validation

The tool and intent of validation were shared at the beginning of the tool validation process. The tool was shared as an Excel file with the respondents so that they could test it efficiently. After sharing the files, an in-depth discussion was organized over the phone for better feedback. A feedback form was also shared with the respondents to know their views.

- Email
- Full Name
- Current Organization
- Current Role
    - Consultant / Advisor
    - Academician
    - Architect / Designer
    - Subject Matter Expert
    - Other:
- Education Qualification
    - Bachelor's degree
    - Master's degree
    - Ph.D.
    - Other:
- Years of experience
    - 0 - 5
    - 5 - 9
    - 10 - 14
    - 15 - 19
    - 20 and more

- Please rate the following statements based on the effectiveness and accuracy of the tool, on a scale from 1 - 5, with 1 being the lowest and 5 being the highest.
    - Do you agree with the scoring system?
    - The tool is suitable for the pre-construction/ early design phase
    - The tool can be used in professional practice
    - The tool has incorporated all expected criteria
    - The tool is compatible with environmental, social, and economic metrics.
    - The tool can achieve a holistic, sustainable design approach
    - The user needs aid/ assistance to use the tool.
    - Rate the tool based on your perspective.
- Please rate the following statements based on the efficiency and utility of the tool, on a scale from 1 - 5, with 1 being very poor and 5 being excellent.
    - The user finds the tool is productive
    - The tool needs a reasonable amount of time to be utilized
    - The tool is easily comprehensible in design and structuring
    - The tool is easy to use and navigate between categories
    - The tool is informative and resourceful
    - The information provided in each section is clear.

A few open-ended questions were asked in the form:

- What component is missing from the tool? What elements of the tool are not necessary?
  (Any absent element/specification/ theme)
- What, if anything, did you like about the tool, and what did you dislike?
- Is there any other issue or problem needed to be addressed?
- Any suggestions or feedback
- If you want to specify any other detail, kindly mention it here. If you are willing to provide the same through in-depth discussions, kindly mention your contact details.

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ANNEXURE

DASH: VERSION I

7.4 Annexure D: DASH V1

DASH : Sustainable Design Assessment Tool for Housing
Research Project: Sustainable Design Assessment Framework For Housing In India
Developed by: Kratika Piparsania
Research Scholar , Department of Design, IIT Guwahati

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Introduction

This tool intents to help assess the sustainability performance, w.r.t. environmental, social and economic aspects of housing. The user guide and toolkit present key issues identified through survey and interviews with residents, that tries to bridge the gap and bring out a holistic framework for sustainable design assessment.
The proposed solution and design guidelines are the outcomes of intense research, survey and analysis.This tool might not include all the possible solutions but has attempted to fill the critical gap in the green building rating systems and comes second to it.
The toolkit covers seven categories of effect, which were identified as they have the most significant potential to reduce a building's environmental effect and to remove the most frequently met problems and barriers in a balanced sustainable design:

Site Planning and Sustainability	Water and Waste Management	Social Co-relations	Cultural and Perceptual	Energy and Resource Management	Health and Wellbeing	Innovation

Each category is divided into multiple subsections for a more thorough analysis. For each subsection, numerous sections covers the intent and assessment criteria is measured to fulfill the requirement this category. Other sections include the analysis method,compliance, reference sources, and other required criteria for evaluation and result.

Start using the Assessment Tool by clicking on the User's Guide tab.

After completing the evaluation, Toolkit users will have a tabulated set of design criteria that will serve to encourage sustainable development and green construction, as well as prevent the building community from growing in accordance with the sustainable design goals. Following the completion of the evaluation, the Toolkit assists architects in charting a transparent and open path for addressing potential design revisions with clients and the local community. The Toolkit can assist the user in developing a strategy for adopting the essential criteria and allowing for adjustments that will allow for more sustainable design and construction. In doing so, local governments can find ways to encourage developers, contractors, and design professionals to plan for and use sustainable design tools and techniques.
The Resource Guide refers to studies, research, publications, model codes/ordinances, and organizations that provide additional tools and strategies to architects and designers seeking more knowledge on sustainable design and green construction. The Resource Guide includes resources for each Toolkit category tab as well as a section on green building and design.

DASH : Sustainable Design Assessment Tool for Housing
Research Project: Sustainable Design Assessment Framework For Housing In India
Developed by: Kratika Piparsania
Research Scholar , Department of Design, IIT Guwahati

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User Guide

For each subcategory, i.e. "Natural topography and vegetation under "Site planning and neighbourhood" worksheet:

For each subcategory, i.e. "Natural topography and vegetation under "Site planning and neighborhood" tab:

1. Read the intent and objectives.
2. Read and comprehend the pointer used to measure this sub-category's success or failure.
3. Understand the assessment criteria and performance benchmarks to be followed.
4. You may evaluate the design using the assessment criteria by choosing the option from the drop-down at the “assigned score“ that fits best to you. Score will display at the end of every subcategory and the total score.
5. The final sheet, " results" will present your score for all categories together.
6.For reference, we have already run a demo and the scores in all categories and sub-categories are assigned. You can see the final analysis in the result section.
7. The scoring for the entire sheet and every sub-section are on a scale ranging from "negative" to "Best Practice" with values (-1, 0,3, 5). All criteria within each category have been assigned equal weightage (i.e., 3 for good practice) except for innovation which is 1.
8. Each score is displayed in a color rating in the final column as green, light green, yellow, or red where in green shows the best possible practice and must continue with it; light green- shows good practice, yellow shows minimum requirements fulfilled and red shows significant need of improvement.
9. Repeat the process until all sections are answered.
10. Review the steps for each category from 1 to 7.
11. If you wish to use the tool and test it for personal project, you can ask for an editable file.

The totals for each colour are calculated and is reported after each subcategory's data, as well as the totals for the overall category at the bottom of the worksheet.
The last tab, "Result," provides a concise summary of all of the data, split down by category, as well as a chart.
This tool may be expanded or changed to meet your design requirements. As a result, if you need to add parts or areas that are not currently covered by the assessment tool, you may do so in the future based on your input, and you can copy and paste the drop down options and formulae to build the automated graphical representations and summary tables.

Index	Category	Criterion name	Completion Check
1	**Site Planning and Sustainability**	Local Building Regulations	-
		Natural Topography & Vegetation	
		Access to Amenities	
		Low Impact Design Strategies	
		Soil Erosion Control	
		Green Education & Awareness	
2	**Water and Waste Management**	Rainwater Harvesting	
		Water Metering	
		Waste water management	
		Separation of House-hold Waste	
		Handling of Construction & Demolition Waste	
3	**Social Co-relations**	Safety and security	
		Accessibility: Transportation and parking	
		Regional Priority	
		Interactive dwellings	
		Universal Accessibility	
4	**Cultural and Perceptual**	Visual Privacy	
		Connection with local values	
		Density and crowdness	
		Local material and technology	
		Spatial efficiency	
5	**Energy and Resource Management**	Energy Optimization	
		Alternate Water Heating system	
		Use of Alternative Material	
		Building Life-Cycle Impact Reduction	
		Renewable Energy	
		Operation and maintainance	
		Construction management practices	
6	**Health and Wellbeing**	Minimum Indoor Air Quality Performance	
		Daylighting	
		Noise and Acoustic Comfort	
		Thermal comfort	
		Promoting physical well being	
7	**Innovation**	Innovation	

Site Planning and Sustainability				
Local Building Regulations				
Intent		To ensure that the building(s) complies with necessary statutory regulatory codes.		
Compliance		Design and execute the project as per the local building bye-laws.		
Indicator		Following building bye-laws and other regulatory codes		
Assessment Criteria		Site plan and as-built drawings approved by local Government authority		
		Approved building plan/ site plan from regulatory body or Attested copies of all drawings from Principal Architect		
		Declaration from developer to build as per local regulations.		
		Photographs at site level and building level		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Design and execute the project as per the local building bye-laws. (Fulfilling assessment criteria 1)	1	-1
Minimum practice		Design and execute the project as per the local building bye-laws. (Fulfilling assessment criteria 1 and 2)	2	0
Good Practice		Design and execute the project as per the local building bye-laws. (Fulfilling assessment criteria 1,2 and 3)	3	3
Best Practice		Design and execute the project as per the local building bye-laws. (Fulfilling all assesment criteria)	4	5
Final Score				0

Natural Topography & Vegetation				
Intent		To minimize impact to the natural topography of the site and to promote local habitat and bio-diversity there by to reduce the related long-term environmental impacts		
Compliance		Vegetation on ground and built-in structures through landscaping and land use plan		
Indicator		Following land use and landscaping guidelines as per regulatory code		
Assessment Criteria		Vegetation on Ground surface		
		Vegetation on Ground & Built structures		
		The project has to meet local-bye laws if there is a requirement of maintaining minimum vegetation / landscaping on the ground.		
		Area break up calculations (approximate) indicating the total site area, area with natural topography / vegetation on ground + built-structures.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Retain Natural topography* or Vegetation or Develop Vegetated green spaces only on ground for atleast 15% of the site area.	15%	-1
Minimum practice		Retain Natural topography* or Vegetation or Develop Vegetated green spaces only on ground for atleast 20% of the site area.	20%	0
Good Practice		Projects have option to include vegetation / greenery on ground and built-structures such as podium, roof surfaces, vertical greenery to meet atleast 30% of the site area as compliance.	30%	3
Best Practice		Projects have option to include vegetation / greenery on ground and built-structures such as podium, roof surfaces, vertical greenery to meet atleast 40% of the site area as compliance.	40%	5
Final Score				5

Access to Amenities				
Intent		To reduce the negative environmental impact due to emissions from automobiles by providing basic house-hold amenities, thereby, enhancing the quality of life.		
Compliance		Site must access to atleast six basic house-hold amenities, within a walking distance of 1 km from the building entrance.		
Indicator		Must adhere guidelines and local regulations as per National Building Code 2016 and Model Building Bye-Laws 2016		
Assessment Criteria		Basic amenities include : Grocery store / Super market, Bank/ ATM, Medical clinic/ Hospital, Bus stop / Railway station/ Metro station/ Auto stand, Park / Garden or Playground / Jogging track/ walking , Place of Worship Educational institutions (Pre-school, School, etc.,), Refueling station , Restaurants, Salon, Clubhouse, Stores such as clothes, electrical, stationary, milk booth, pharmacy, etc., , Laundry services, Sports club / Fitness center / Gym		
		Within the building : one common toilet for service staff & visitors. (for less than 200 dwelling units) or as per regulation. For designing differently abled toilets the project must adhere to the local regulations or National Building Code 2016		
		Seating area in common spaces		
		Play area for children to include tot-lot play equipment which is permanently installed		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Site must access to atleast to the following basic house-hold amenities, within a walking distance of 1 km from the building entrance and must include assessment 2,3,4 if it's a multiple dwelling unit	**< 6**	-1
Minimum practice			**6**	0
Good Practice			**> 6**	3
Best Practice			**> 6 + Others**	5
Final Score				3

Low Impact Design Strategies				
Intent		To promote design strategies that enable the project to factor in ways by which natural site features (topographical/microclimatic) can be protected and/or incorporated into the project design.		
Compliance		To show reduction in environmental impact by adoption of various low-impact planning and design strategies		
Indicator		Low-impact planning , passive architecture and design strategies		
Assessment Criteria		To reduce environmental impact by adoption of various low-impact planning Application of any active or passive design strategy . (See the appendix table 1 and 2 for strategies)		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Allocation for low impact design strategies with passive strategy	0	-1
Minimum practice			2	0
Good Practice			3	3
Best Practice			5	5
Final Score				0

Soil Erosion Control				
Intent		Control soil erosion and sedimentation thereby, reducing negative impacts to the site and surroundings.		
Compliance		Adopting appropriate measures		
Indicator		Develop appropriate measures to address soil erosion, pre construction and post occupancy.		
Assessment Criteria		Soil erosion control measures for pre-construction and during construction must conform to the best management practices highlighted in the National Building Code 2016 of India. Kindly refer to Landscape practices in National Building Code 2016 of India, Chapter 11 – Approach to Sustainability, No. 7 – External Development & Landscape and Chapter 10, Part 10, Section 1 – Landscape Site Planning. No. 4- Protection of Landscape during Construction and No. 5. General landscape development.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Fertile topsoil to be stockpiled prior to construction, for reuse later either on site or sold/donated for use off-site.	0	-1
Minimum practice			1	0
Good Practice			2	3
Best Practice		Develop a storm-water management plan during construction to ensure that the storm-water run-offs during construction are filtered to remove the TSS* prior to conveying into the municipal storm-water drain	3	5
Final Score				0

Green Education & Awareness				
Intent		Educate the workforce during construction phase and occupants post construction to sustain the green features through the life of the building, thereby reducing the negative impacts associated on environment		
Compliance		Awareness of green home guidelines to occupants		
Indicator		Declaration from owner stating the schedule of awareness sessions planned and executed		
Assessment Criteria		a.Awareness sessions for construction workforce on green & safety measures b. Display signages indicating envisaged green features		
		a. Project brochure highlighting the green features proposed b. Awareness sessions to prospective occupants c. Circulate green home guidelines d. Permanent signages highlighting the implemented green features		
Reference/ Guide		Model Buildling Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Declaration from owner stating the schedule of awareness sessions planned + Photographs of the signages displayed in construction site, as applicable and acknowledgment of green home guidelines by occupants	0	-1
Minimum practice			1	0
Good Practice			2	3
Best Practice			3	5
Final Score				-1
Final Score				**7**

Water and Waste Management

Rainwater Harvesting

Intent	Enhance ground water table and reduce municipal water demand through effective rain water management.
Indicator	Design rainwater harvesting system and High Ground Water Table
Assessment Method	To calculate total rainwater harvesting potential
Relevant Information/ Assessment Criteria	Consider Rainwater Harvesting Guidelines (as and when available) from the National Building Code , Part 11 - Approach to Sustainability, Section 7.2 - Rainwater Harvesting Surface Run-off.
Reference/ Guide	National Building Code 2016, Model Building Bye-Laws 2016

Performance Benchmarks

	Indicator	Criteria : One-day Rainfall (% of Average Peak Month Rainfall)	Score
Negative	The total rainwater harvesting system to capture at least 'one-day rainfall*' run-off volume from roof and non-roof areas AND Rainwater is recharged into the ground water aquifer with 8m depth and has a filtration system installed	Avg peak rainfall per month up to 250 mm : 12% ; 251-300 : 10% ; 351 - 500 : 8% ; 501-700 : 6 % ; 701-above : 4 %	-1
Minimum practice		Avg peak rainfall per month up to 250 mm : 10 % ; 251-300 : 12.5 % ; 351 - 500 : 10% ; 501-700 : 7.5 % ; 701-above : 5 %	0
Good Practice		Avg peak rainfall per month up to 250 mm : 18% ; 251-300 : 15 % ; 351 - 500 : 12v% ; 501-700 : 9 % ; 701-above : 6 %	3
Best Practice		Avg peak rainfall per month up to 250 mm : 21 % ; 251-300 : 17.5 % ; 351 - 500 : 14 % ; 501-700 : 10.5 % ; 701-above : 7 %	5
Final Score			3

Water Metering				
Intent		To support water management and identify opportunities for additional water savings by tracking water consumption.		
Compliance		Quantify water used in each of the dwelling units and common area applications.		
Indicator		Install permanent water meters that measure the total potable water use for the building and associated grounds.		
Assessment Criteria		Install Water meters at dwelling unit level (Kitchen, Toilets) : 75 % - 100 % of the Dwelling unit consumption		
		Other Area Water meters (any 3 measures) for the following applications: STP treated water , Landscape water consumption, Water consumption in club house , Captured rain water reuse		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Install Water meters at dwelling unit level (Kitchen, Toilets) : 75 % - 100 % of the Dwelling unit consumption AND/OR Other Area Water meters (any 3 measures) for the following applications: STP treated water , Landscape water consumption, Water consumption in club house , Captured rain water reuse	less then 75%	-1
Minimum practice			75%	0
Good Practice			75 % - 100 % and 1 criteria	3
Best Practice			75 % - 100 % and 2 or more criteria	5
Final Score				0

Waste water management				
Intent		Reduce consumption of potable water and waste water generation to minimize the burden on municipal water supply		
Compliance		Waste Water Treatment and its reuse		
Indicator		On-site treatment system , reusing options		
Assessment Criteria		Provide an on-site treatment system to treat atleast 50% of waste water generated in the building/ campus, to the quality standards suitable for reuse as prescribed by Central (or) State Pollution Control Board		
		Provide separate plumbing lines for reuse of treated waste water available from InSite waste water treatment plant for flushing requirements.		
		Reuse treated waste water for flushing, landscaping, car washing or any other purposes, as applicable. The treated grey water for reuse must conform to the water quality standards as per the CPCB norms or local Government Authority.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016 , CPCB Norms		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		On-site treatment system to treat atleast 50% of waste water generated in the building,; Percentage of waste water treated : X Percentage of waste water used : Y	< 50 % and < 50 %	-1
Minimum practice			Equal to 50 % and 50 %	0
Good Practice			> 50 % and > 50 %	3
Best Practice			> 95 % and > 75 %	5
Final Score				0

Separation of House-hold Waste				
Intent		Facilitate segregation of house-hold waste at source so as to prevent such waste being sent to land-fills.		
Compliance		plan showing the location of proposed waste bins at individual level.		
Indicator		Provide separate bins in every dwelling unit		
Assessment Criteria		Provide separate bins in every dwelling unit to collect dry waste (paper, plastics, metals, glass, etc.,) and wet waste (organic) at each dwelling unit and common areas (as applicable) in the building(s)/ campus. Also, provide a common facility at community level with separate bins to collect waste which covers Dry Waste, Wet waste, Batteries, 'e' waste , Lamps		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Providing waste bins at individual level.	0	-1
Minimum practice			1	0
Good Practice			2	3
Best Practice			3	5
Final Score				5

Handling of Construction & Demolition Waste				
Intent		Encourage practices to manage construction waste, thereby, avoiding waste being sent to land-fills.		
Compliance		strategies to be implemented to handle construction waste		
Indicator		Preventing waste going to landfills		
Assessment Criteria		Avoid atleast 50% of the waste generated (by either weight or volume) during construction from being sent to landfills.		
		Excavated earth & stones should not be considered under this credit, as these are natural resources.		
		Temporary materials such as materials used for form-work, scaffolding etc., shall not be considered for credit calculations.		
		Declaration letter from scrap vendors / haulers cannot be considered. Project need to submit gate pass / challans / receipts related to waste disposed		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Percentage of Construction Waste Materials Handled	50%	-1
Minimum practice			65%	0
Good Practice			80%	3
Best Practice			95%	5
Final Score				3
Final Score				**11**

Social Co-relations

Safety and security				
Intent		To access and stimulate plan for transportation facilities and services like hospitals, shops, schools etc.		
Compliance		Design and contract documentation, local fire department.		
Indicator		Risk level for occupants in the most vulnerable part of the building.		
Assessment Criteria		Provision for fire fighters to access key parts of the building from exterior and interior points; adequacy of means of egress; fire rating of key systems.		
		The minimum clear width 1.5m , minimum tread width 250 mm and maximum riser of staircases 190 mm for buildings shall be as given as below (see also Part 4 'Fire and Life Safety of National Building Code 2016).		
		All aspects of exit requirements for corridors, doors, stair cases, ramps, etc. in respect of widths, travel distance shall be as per Part 4 'Fire and Life Safety' of National Building Code 2016		
		Building elements/components such as walls, columns, beams and floors shall have the requisite fire resistance rating in accordance with the accepted standards at Tables 2 to 18 of Part IV of the National Building Code 2016		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		To fulfil criteria from each category mentioned in the assessment list	0	-1
Minimum practice			1	0
Good Practice			2	3
Best Practice			3	5
Final Score				0

Accessibility: Transportation and parking				
Intent		To encourage development in locations shown to have multimodal transportation choices or otherwise reduced motor vehicle use, thereby reducing greenhouse gas emissions, air pollution, and other environmental and public health harms associated with motor vehicle use. and To minimize the environmental harms associated with parking facilities, including automobile dependence, land consumption, and rainwater runoff.		
Compliance		Provide adequate transportation choices and ventilation in basements, encourage use of hybrid vehicles and bicycles.		
Indicator		Use facilities for transportation and parking to reduce carbon footprint		
Assessment Criteria		Do not provide off-street parking, Do not exceed the minimum local code requirements for parking capacity, Provide parking capacity that is a 30% reduction below the base ratios recommended Consultants Council, Provide dedicated parking for carshare vehicles, Unbundling Parking, promoting alternatives to conventionally fueled automobiles.		
		Ventilation for Basements , common Electric charging facility and bicycle parking		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, SAE Surface Vehicle Recommended Practice J1772		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Provide axial fans, CO sensors and meet minimum air changes per hour (ACH*) requirements as per NBC 2016 in the basement parking spaces	0	-1
Minimum practice		Provide common charging facility to cater to minimum 20-30% of the four wheelers & two wheelers in the building.	1	0
Good Practice		Functional entry within 400-800m walking distance of existing or planned bus, streetcar, or informal transit stops,	2	3
Best Practice		No Off-Street Parking and Reduce Parking, Carshare and Unbundling Parking	3	5
Final Score				3

Regional Priority				
Intent		To address geographically specific environmental, social equity, and public health priorities.		
Compliance		To fulfil any 1 criteria from each category in the following list		
Indicator		To promote regional values and technology		
Assessment Criteria		Public health : Clean and healthy environments for building occupants., Promote safe and healthy site area for construction workers, Reduce use of chemical and toxic exposures throughout the supply chain, Taking care of health of surrounding communities, Mitigate climate change to benefit global populations.		
		Social Equality : Creating fairer, healthier, and more supportive environments for those who work/live in the project, Responding to the needs of the surrounding community to promote a fair distribution of benefits and burdens, Promoting fair trade, respect for human rights, and other equity practices among disadvantaged communities , Providing basic facilities like toilets, storage space and medical help		
		Environmental concerns: Optimize energy performance, Heat Island Effect-Non Roof, Outdoor Water use Reduction, Building life-cycle impact reduction		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		To fulfil atleast 1 criteria from each category in the following list : (3 minimum)	2	-1
Minimum practice			3	0
Good Practice			4	3
Best Practice			5	5
Final Score				3

Interactive dwellings				
Intent		Idea for residential project and building layout in a way that encourages social exchange between residents and promote security and walkability in the vicinity		
Compliance		Design and contract documents.		
Indicator		Common gathering spaces like open veranda, parks , walking paths		
Assessment Criteria		Availability of common use and gathering space in the building or between group of units in the neighborhood by arranging units to create shaded mutual semi-public zones where neighbors can meet.		
		Limit number of dwelling that share a semi-public zone or courtyard to no more than 12. And limit the number of dwellings that share one entrance to 8 units. In multi-story development. It is always favorable to design 3 or 4 levels		
		Arrange dwelling entrances in the street or in one level of an apartment block to be overlooking and share one regular shape landing or lobby		
		Gear views from room's windows, balconies and terraces to street and nearby playing ground or gardens to maximize social interaction and increase safety and security.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		The location of the housing entrances is clear to less than 25% of the other entrances to the housing on the street or within the same semi-public area common to buildings with floors	**< 25%**	-1
Minimum practice		The location of the entrance to any housing can be seen from 50% of the entrances of other dwellings on the street or within the same common semi-public area or / and there are more than 12 housing units that share a common use area or one entrance	**25 % - 50 %**	0
Good Practice		The location of the housing entrance can be seen from 50% to 74% of other housing on the street or within the same common semi-public area with about 12 participants in the same entrance to the semi-private area or the entrance to the building	**50 % - 75 %**	3
Best Practice		The location of the housing entrance can be seen from 75% of other housing on the street or within the same common semi-public area with no more than 8 housing units that share the same entrance to the semi-private area or building with 4 floors of a maximum of inhabited floors	**≥75%**	5
Final Score				3

Universal Accessibility				
Intent		The intent of this criterion is to encourage the adoption of measures that make the built environment barrier free and accessible to all, including people who are differently abled, children's and elderly persons.		
Compliance		Review of construction documents by a specialist in universal access design.		
Indicator		The scope and quality of design measures planned to facilitate access and use of building facilities by persons with mobility or perceptual disabilities.		
Assessment Criteria		Submisison of details, floor plan and site plan in .dwg format demonstrating that the project incorporates design measures		
		Submit a narrative along with date-stamped photographs highlighting the measures implemented in the project.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, Harmonized Guidelines and Space Standards for Barrier Free Built Environment for Persons with Disability and Elderly Persons, 2016.		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		All key facilities, including outdoor facilities, entry points and hallways, are accessible to wheelchair users and visually impaired persons.	0	-1
Minimum practice		All key facilities, including outdoor facilities, entry points and hallways, are accessible to wheelchair users and visually impaired persons. In residential occupancies, design documentation indicates the percentage of dwelling units with accessible entry points, bathrooms and kitchens, with easy access from ground floor entry points, will be at least 5%.	1	0
Good Practice		All key facilities, including outdoor facilities, entry points and hallways, are accessible to wheelchair users and visually impaired persons. In residential occupancies, design documentation indicates that the percentage of dwelling units with accessible entry points,same as above be at least 20%.	2	3
Best Practice		All key facilities, including outdoor facilities, entry points and hallways, are accessible to wheelchair users and visually impaired persons. In residential occupancies, design documentation indicates the percentage of dwelling units with accessible entry points, same as above be at least 30%.	3	5
Final Score				-1
Final Score				**8**

Cultural and Perceptual				
Visual Privacy				
Intent		To assess the level of privacy in bedroom and living areas of dwelling units in the building.		
Compliance		Review of analysis prepared by the design team and Design documentation, location and type of adjacent buildings.		
Indicator		The percentage of the number of housing units in which the bedrooms and living rooms are exposed and located within sight. Or windows of adjacent buildings located at a distance less than the recommended separation distance		
Assessment Criteria		A minimum of 9m separation should be provided between the living area windows of facing dwelling units.		
		Where the distance between windows or balconies/verandas of dwelling units is less than 12m, direct views between living area rooms of dwelling units into the principle area of private open space of other adjoining units should be screened or obscured.		
		Views may be obscured through the use of solid fences, semi-permeable screening (e.g. lattice), or planting, and by offsetting the placement of windows on facing buildings so as not to create direct views between them.		
		Site layouts should ensure shared driveways have a line of separation of at least 3m from bedroom windows.		
		Separation could be achieved either by distance or changes in levels. Provide semi-open and semi-private areas of the dwelling with enough visual privacy. This includes terraces, balconies not adjacent to other opening/ balconies from nearby buildings. And for back gardens have high enough boundary or tree line to protect them.		
		Relocate semi-open and semi-private areas of the dwelling to face street or avoid locating them next to semi-private areas and direct contact from windows of the next building.		
		Applying maximum grading allowance where the position of the building garden level above ground do not exceed the original level of site before development to decrease exposure to neighbors' semiprivate zones and gardens.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		The percentage of dwelling units whose bedroom and living areas are open to horizontal or downward views by others, from a point within 20 m of the exterior windows :	≥ 75 %	-1
Minimum practice			50 - 74 %	0
Good Practice			24 - 49 %	3
Best Practice			≤ 25 %	5
Final Score				0

Connection with local values		
Intent		To ensure that the urban design and architecture of buildings is compatible with local cultural values.
Compliance		Subjective assessment by an experienced third-party design professional and/or sociologist.
Indicator		Expert assessment of the degree to which new features, systems and materials are consistent with local cultural values related to urban design and architecture, including both functional and aesthetic aspects.
Assessment Criteria		Discussion with client and design team by outside designer who has knowledge of the urban region.
		Relevant issues include building uses, degree of access by public to site and to interior, degree of design openness.
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016
Performance Benchmarks		
	Assessment	Score
Negative	Architectural features of the Design are incompatible with existing cultural values related to urban design and architecture, including both functional and aesthetic aspects.	-1
Minimum practice	Architectural features of the Design are marginally compatible with existing cultural values related to urban design and architecture, including both functional and aesthetic aspects.	0
Good Practice	Architectural features of the Design are fully compatible with existing cultural values related to urban design and architecture, including both functional and aesthetic aspects.	3
Best Practice	Architectural features of the Design are an outstanding examples of compatibility with existing cultural values related to urban design and architecture, including both functional and aesthetic aspects.	5
Final Score		3

Density and crowdness			
Intent	To encourage the efficient use of urban land, within the context of an urban development plan. Without increasing the feeling of over crowdedness.		
Compliance	Review of site and development plans		
Indicator	Reducing feeling of crowdedness expressed by the optimal use of spaces between buildings and increasing setbacks proportionally with buildings heights		
Assessment Criteria	Consider the possible development of adjacent sites and ensure that the proposed development is guards against any potential adverse effects. Checking the neighbor's rights and building envelopes of adjacent sites will allow principal living spaces and primary views to be located where they will not be blocked. Although access point location may look obvious and convenient consider changing or moving the entrance to create more accessible entrance by less-abled demographics or increase social interaction or provide more privacy for adjacent neighbors. ventilation and privacy for all adjacent dwelling, where flexible setbacks to match or be consistence with nearby buildings Building height variance in the building to allow desirable sun to reach your neighbors.		
Reference/ Guide	National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks			
	Assessment	Criteria	Score
Negative	Position the level of spaces between the building and street on the access level of the street to promote the social use of that space.	0	-1
Minimum practice	Create clear hierarchy and distinct of private zones inside the house, to overlooking semi-private and semi-open zones like the garden and balconies and semi-public areas that is shared between group of buildings or dwellings to completely public zones of pedestrian paths and streets	1	0
Good Practice	In multi-story development. It is always favorable to design 3 or 4 levels only that offer beside the semi-private and open zone a direct connection to street.	2	3
Best Practice	Proportional setbacks between buildings where the distance between tow buildings should be half of the average heights of them. (H1+H2/2)= min Distance between these buildings.	3	5
Final Score			3

Local material and technology				
Intent		To assess the extent to which traditional local materials and construction techniques will used in the execution of the project. thereby minimizing the associated environmental impacts resulting from transportation.		
Compliance		Design documents		
Indicator		Percentage of the non-structural elements of the building constructed using traditional local materials and construction techniques.		
Assessment Criteria		Estimate of percentage of traditional local materials to be used relative to total non-structural materials, by value.		
		Review by an outside design team of an analysis prepared by the design team.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, BTPMC		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Ensure atleast X % of the total building materials (by cost), used in the building(s)/ campus, are manufactured within a distance of 400 km	< 50 %	-1
Minimum practice			equal to 50 %	0
Good Practice			Between 50 - 75 %	3
Best Practice			> 75 %	5
Final Score				3

Spatial efficiency				
Intent		To encourage the efficient utilization of space within buildings.		
Compliance		Design and contract documentation, including floor plans for all floors with varying net areas.		
Indicator		The ratio of directly functional net areas to total net area in each occupancy. Total Net Areas exclude only structure and building envelope areas; Net Functional Areas (NFA) exclude interior garages, vertical circulation and building mechanical rooms.		
Assessment Criteria		Net areas for all floors with varying net areas.		
		Calculation of net to gross areas for all floors of varying net area.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		The ratio of directly functional net areas to total net area within the occupancy, for the average of all floors, according to design documentation.	72	-1
Minimum practice			75	0
Good Practice			84	3
Best Practice			90	5
Final Score				3
Final Score				**12**

Energy and Resource Management

Energy Optimization

Intent		Enhance energy efficiency of the building(s) to reduce environmental impacts from excessive energy use.
Compliance		Submission and review of all documents at early stages
Indicator		Ensure that the project demonstrates compliance with the mandatory requirements of Eco Niwas Samita 2018 (ECBC -R)
Assessment Criteria		The project should design the building envelope measures as per Eco-Niwas Samhita 2018 (ECBC-R).
		The project must ensure that the interior, exterior, common and parking area lighting power densities are reduced by atleast 25% over the baseline values through 'building area method'.
		All air conditioners (single unit) must be BEE 4-star rated as per the latest notification or/BEE 5 star / Inverter based and Centralized air-conditioning system(s) must be efficient by atleast 10% over the baselines of ECBC- R / ECBC 2017. (Applicable for project only if 25% of the total regularly occupied spaces are airconditioned, excluding kitchen)
		For Space Heating Systems : Unitary heat pumps must meet the baseline criteria of ECBC-R/ ECBC 2017 and all Non-electricity based heating system should have a minimum thermal efficiency of 70%
		All non-emergency exterior & common area lighting such as façade, pathways, landscaping, surface and covered parking, street lighting, staircases should have atleast one of the following in common areas & common toilets: Day light sensor, Occupancy/ Motion sensor ,Timer based controls
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, Eco Niwas Samita 2018

Performance Benchmarks

	Assessment	Criteria	Score
Negative	For building envelope, Residential envelope transmittance value (RETV*) for building envelope (except roof) shall be 15 W/m²K , U value of Roof assembly of 1.2 W/m²K.Reduction in Interior, Exterior Common & Parking Area LPDs from Baseline Values ≥ 25%.Efficiency in Centralized Air-conditioning Systems from Baseline Values ≥ 10% + Lighting control + space heating systems	0	-1
Minimum practice	For building envelope, Residential envelope transmittance value (RETV*) for building envelope (except roof) shall be 15 W/m²K , U value of Roof assembly of 1.2 W/m²K.Reduction in Interior, Exterior Common & Parking Area LPDs from Baseline Values ≥ 25%.Efficiency in Centralized Air-	1	0

		conditioning Systems from Baseline Values ≥ 10% + Lighting control + space heating systems		
Good Practice		For building envelope, Residential envelope transmittance value (RETV*) for building envelope (except roof) shall be 13 W/m²K , U value of Roof assembly of 1.0W/m²K.Reduction in Interior, Exterior Common & Parking Area LPDs from Baseline Values ≥ 30%. Efficiency in Centralized Air-conditioning Systems from Baseline Values ≥ 20% + Lighting control + space heating systems	2	3
Best Practice		For building envelope, Residential envelope transmittance value (RETV*) for building envelope (except roof) shall be 13 W/m²K , U value of Roof assembly of 1.0W/m²K. Reduction in Interior, Exterior Common & Parking Area LPDs from Baseline Values ≥ 30%. Efficiency in Centralized Air-conditioning Systems from Baseline Values ≥ 20% + Lighting control + space heating systems	3	5
Final Score				3

Alternate Water Heating system				
Intent		Encourage use of alternate water heating systems to improve energy efficiency.		
Compliance		Provide any one or combination of the below technologies for atleast 50 % of hot water		
Indicator		Awareness and implementation of alternate energy source		
Assessment Criteria		The minimum hot water requirement for domestic purposes should be considered as 20 liters per person per day.		
		The minimum temperature requirement of hot water to be considered for domestic applications can range between 35-40 deg C.		
		Alternate source could be : Natural Gas (or) LPG based systems, Heat pump with minimum of COP 3.2 , Solar water heating systems		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, ECBC- R 2018		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Hot water through alternative heating systems as a percentage of total hot water requirement of the building(s)	> 50 %	-1
Minimum practice			50%	0
Good Practice			75%	3
Best Practice			95%	5
Final Score				0

Use of Alternative Material				
Intent		Encourage use of alternative construction materials to conserve natural resources and thereby reduce environmental impacts and minimize use of new wood-based products, thereby reducing impacts of deforestation.		
Compliance		Submission and review of all documents at early stages		
Indicator		Use of alternate materials for external and internal site work		
Assessment Criteria		Ensure new wood-based products (by cost) used in the building : Rapidly renewable or Composite / Agri based wood** / Recycled waste wood or Wood certified by Forest Stewardship Council (FSC) or Programme for the Endorsement for Forest Certification (PEFC) or equivalent		
		Source atleast 5% -10% of the building construction using alternative materials.		
		Ensure that at least 70% of all roads and vehicular pathways within site premises are constructed with one, or any combination, of substitute materials		
		Ensure atleast 50% - 75% of the total building materials (by cost), used in the building(s), are manufactured within a distance of 400 km.		
		Use atleast 5% - 25% certified green building materials, products, and equipment, so as to reduce dependence on materials that have associated negative environmental impacts.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, ECBC- R 2018		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Not fulfilling any criteria fully	0	-1
Minimum practice		Fulfilling any one of the criteria	1	0
Good Practice		Fulfilling more than 1 criteria	2	3
Best Practice		Fulfilling more than 2 criteria	3	5
Final Score				0

Building Life-Cycle Impact Reduction				
Intent		To encourage adaptive reuse and optimize the environmental performance of products and materials.		
Compliance		Demonstrate reduced environmental effects during initial project decision-making by reusing existing building resources or demonstrating a reduction in materials use through life-cycle assessment.		
Indicator		To Reuse and reduce the over all impact		
Assessment Criteria		For existing building : Maintain the existing building structure, envelope, and interior nonstructural elements of a old building. Must adhere by local bye laws		
		Maintain at least 50%, by surface area, of the existing building structure, enclosure, and interior structural elements for buildings that meet local criteria of abandoned or are considered blight.		
		Reusing the existing building material from on site/ off site, ranging from 25 - 75 %		
		For new construction (buildings or portions of buildings), conduct a life-cycle assessment of the project's structure		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, ECBC- R 2018		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Achieve any one of the above mentioned criteria.	0	-1
Minimum practice			1	0
Good Practice			2	3
Best Practice			3	5
Final Score				-1

Renewable Energy				
Intent		The intent of this criterion is to promote the use of RE in the projects and, thereby, reduce the project's dependency on fuels derived from conventional sources.		
Compliance		Onsite and/ or offsite combination renewable energy system		
Indicator		Awareness and implementation of renewable energy		
Assessment Criteria		Installation of on-site and off-site RE system to offset a part of the annual energy consumption of internal artificial lighting, HVAC, and domestic hot water systems		
		100% of the annual energy consumption of internal artificial lighting, HVAC, and domestic hot water systems is offset through off-site RE systems.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, ECBC- R 2018		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Point weightage for on-site and off-site renewable energy system installation	10%	-1
Minimum practice			15%	0
Good Practice			20%	3
Best Practice			25%	5
Final Score				-1

Operation and maintainance				
Intent		The intent of this criterion is to ensure the incorporation of detailed O&M procedures for various systems in the building.		
Compliance		Methods for designing building envelope components prepared for repair and maintenance		
Indicator		Degree of technical and design difficulty and capital cost requirements linked to expansion possibilities.		
Assessment Criteria		To ensure that a core facility/service group is formed, which will be responsible for the O&M of the building systems and equipment post installation.		
		Ceiling lights installed that can only be accessed and changed out with scaffolding.		
		Lights installed in new buildings that are not accessible at all; ultimately, these will be abandoned when the lamps fail.		
		Lights, pipes or electrical wiring requiring panels, walls or ceiling to be partially or completely cut throw or demolished		
		High-cost, custom lighting fixtures/lamps installed in parking garages. As they fail, these will be replaced with lower-cost fixtures.		
		Rooftop equipment units with no elevator access to bring replacement or maintenance/refilling chemicals or equipment.		
		Trees planted near the building's foundations		
		Lack of enough telephone, electrical, and computer outlets/cables.		
		Equipment, piping, wiring installed easily during construction that is nearly inaccessible after final walls and other appurtenances are completed.		
		High-maintenance equipment installed with no local vendor support.		
		The main pipes lines go underfloor or are cast inside the wall where it's inaccessible after building and will eventually lead to moisture and water leaking inside the envelope.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, ECBC- R 2018		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		No criteria have been meet for future maintenance and efficient operation of the facility.	0	-1
Minimum practice		At least 3 criteria have been meet for future maintenance and efficient operation of the facility.	3	0
Good Practice		At least 5 criteria have been meet for future maintenance and efficient operation of the facility.	5	3
Best Practice		At least 7 criteria have been meet for future maintenance and efficient operation of the facility.	7	5
Final Score				0

Construction management practices				
Intent		The intent of this criterion is to ensure adoption of good management practices on-site during the construction phase.		
Compliance		To optimize resource management and ensure safe practices		
Indicator		Adoption of construction management practices and minimize waste		
Assessment Criteria		Adopt construction management practices (e.g., stacking and storage of construction materials at different stages of construction) and ensure safe disposal of waste generated during construction.		
		Adopt at least two strategies from the list, as given below, to minimize water consumption during construction, : Use gunny bags, ponding technique, or curing compound; Meter and monitor the consumption of water during construction ; Use water-reducing admixtures in concrete mix; Use treated wastewater and/or captured storm water.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, ECBC- R 2018		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Achieve criteria 1 and any two from the second mentioned criteria.	0	-1
Minimum practice			1	0
Good Practice			2	3
Best Practice			3	5
Final Score				3
Final Score				**4**

Health and Wellbeing

Minimum Indoor Air Quality Performance

Intent	To contribute to the comfort and well-being of building occupants by establishing minimum standards for indoor air quality (IAQ).
Compliance	To ensure fresh and good quality air
Indicator	Dwelling-unit ventilation, Exhaust, Naturally Ventilated Spaces
Assessment Criteria	Ensure that the minimum requirements of CPCB (NAAQS) for assessing the quality of fresh air are fulfilled
	Ensure that the minimum requirements of ASHRAE Standard 62.1–2010, Sections 4–7, Ventilation for Acceptable Indoor Air Quantity (with errata), or National Building Code 2016, Volume 2, Part 8, Section 3, for quantity of fresh air are met.
	Ensure continuous monitoring of CO, CO2, temperature, and RH levels such that they meet the permissible thresholds as per ISHRAE standard 10001:2016, for all habitable areas either at space level or at AHU's by installation of sensor(s) deployed with feedback system
	Sensors/monitoring devices
	Display sensors
	Ensure that all interior wall and ceiling finishes (including, but not limited to, primers and paints) have low VOC content and are lead free
	Ensure that all adhesives and sealants used have low VOC content and that interior composite wood products do not have urea–formaldehyde as a bonding resin
	Ensure improved indoor air quality by adopting a minimum of three strategies
Reference/ Guide	CPCB (National Ambient Air Quality Standards [NAAQS]) , National Building Code 2016

Performance Benchmarks

	Assessment	Criteria	Score
Negative	Ensure that all interior wall and ceiling finishes (including, but not limited to, primers and paints) have low VOC content and are lead free and any 1 of the above	0	-1
Minimum practice		1	0
Good Practice		2	3
Best Practice		3	5
Final Score			3

Daylighting				
Intent		To ensure an adequate level of daylight in all essential occupancy areas.		
Compliance		Residential : Single and Multifamily units		
Indicator		Measuring the expected daylight factor in primary occupancy areas.		
Assessment Criteria		Daylight Autonomy requirement (<3000 lux) is met for 100% of the annual analysis hours for 100% of the regularly occupied areas		
		Daylight Autonomy requirement (>300 lux) is met for the annual analysis hours for 100% of the regularly occupied areas		
		WWR does not exceed 60% and the vertical fenestration complies with minimum VLT of 0.27		
		Ensure that the project meets the SHGC compliance /weighted façade average SHGC for each orientation. OR Conduct solar path analysis for windows of AC as well as non-AC spaces, to ensure that the window is completely shaded for the duration between 0900 hours on 15th March to 1500 hours on 15th September		
		Ensure that the SRR does not exceed 5% and SHGC for skylights does not exceed 0.35		
		Ensure that all regularly occupied areas meet or exceed illuminance level between 100 lux and 2000 lux for the minimum percentage of floor area for 90% of the potential day lit time in a year		
		Artificial lighting design to fall within limits (lower and higher range limits) as recommended space/task specific lighting levels as per NBC 2016 and to meet a minimum uniformity ratio of 0.4.		
Reference/ Guide		https://www.teriin.org/sites/default/files/2021-11/Inside_Integrated-daylight-system.pdf, National Building Code 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Fulfill criteria 1, 3, 4 and any other 2	0	-1
Minimum practice			1	0
Good Practice			2	3
Best Practice			3	5
Final Score				5

Noise and Acoustic Comfort				
Intent		To promote occupant's comfort and well-being by providing effective acoustic design and reducing noise impact		
Compliance		Reduce noise impact by HVAC and other envelope acoustic performance		
Indicator		To ensure comfort by reducing noise impact		
Assessment Criteria		In each regularly occupied space, achieve maximum background noise levels from heating, cooling and ventilation systems to ensure they are at or below the following thresholds: 35 dBA for living areas and 45 dBA for kitchens and baths : HVAC background Noise		
		Floor/ceiling assemblies between dwelling units or between a dwelling unit and a public or service area stair, exterior mechanical equipment, or other mechanical equipment space, including boiler rooms, shall be constructed of assemblies with a minimum impact insulation class (IIC) rating of 50		
		Exterior windows in dwelling units, must have a minimum STC rating of 34 and Dwelling unit entrance doors (either from common hallways or the exterior) must have a minimum STC rating of 30. : Envelope Acoustic Performance		
		Walls, partitions and floor/ceiling assemblies separating dwelling units from each other, from adjacent occupancies, from public or service areas, from stairs or from mechanical equipment spaces, including boiler rooms, or elevator or other shafts shall have a minimum sound transmission class (STC) rating of 50. Penetrations or openings in construction assemblies for piping; electrical devices; recessed cabinets; bathtubs; soffits; or heating, ventilating or exhaust ducts shall be sealed, lined, insulated or otherwise treated to maintain the required rating.		
Reference/ Guide		International Electrotechnical Commission (2013) IEC 61672-1:2013 Electroacoustics, National Building Code 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Ensure fulfilling criteria from all assessment indicators mentioned	1	-1
Minimum practice			2	0
Good Practice			3	3
Best Practice			4	5
Final Score				3

Thermal comfort				
Intent		To promote occupant's comfort and well-being by providing quality thermal comfort.		
Compliance		The project meets the thermal comfort requirements for all regularly occupied spaces		
Indicator		To ensure comfort by maintaining thermal performance		
Assessment Criteria		For each dwelling unit : Heating and cooling controls are installed in every unit		
		All regularly occupied spaces (air conditioned spaces) meet the thermal comfort requirements as per NBC 2016, ASHRAE 55, or the Indian Adaptive Comfort model ensuring that the maximum number of unmet hours do not exceed 300		
		All the regularly occupied spaces (Non-air-conditioned Spaces with Operable Windows)meet the thermal comfort requirements as per NBC 2016, ASHRAE 55 or the Indian Adaptive Comfort model for 90% of the occupied hours for buildings in composite, moderate, hot and dry, and cold climates, and 60% of the occupied hours for buildings in warm and humid climate		
		The optimum size/number of fans are installed in rooms of different sizes in accordance with National Building Code 2016.		
Reference/ Guide		National Building Code 2016, ASHRAE 55, The Indian Adaptive Comfort		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Demonstrate that the project meets the thermal comfort requirements for all regularly occupied spaces	0	-1
Minimum practice			1	0
Good Practice			2	3
Best Practice			3	5
Final Score				3

Promoting physical well being				
Intent		Promote occupant well-being so as to enhance physical, emotional and spiritual well-being of building occupants		
Compliance		the recreational facilities provided based on the number of occupants.		
Indicator		Provision of well-being facilities		
Assessment Criteria		The project has occupant well-being facilities (such as gymnasium, aerobics, yoga, meditation, swimming pool or any indoor / outdoor games) to cater to at least 2.5% of building occupants at any point during the day		
Reference/ Guide		-		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		The project has occupant well-being facilities (such as gymnasium, aerobics, yoga, meditation, swimming pool or any indoor / outdoor games) to cater to at least X % of building occupants at any point during the day	> 2.5 %	-1
Minimum practice			Equal to 2.5 %	0
Good Practice			2.5 - 5 %	3
Best Practice			> 5 %	5
Final Score				0
Final Score				**14**

Innovation				
Innovation				
Intent		To promote adoption and implementation of innovative strategies to enhance the sustainability quotient of the project.		
Compliance		Detailed depiction of innovation or innovative performance/ strategies implemented in the building.		
Indicator		To encourage projects to achieve exceptional or innovative performance.		
Assessment Criteria		Initiative for Gender neutral design/ Heritage conservation / safety and security		
		Any comprehensive strategy / dynamic performance		
		Strategy to enhance the overall sustainability/ any sustainable design practice/ zero waste management / using EPD (min 5)		
		Regional priority consideration		
		Voluntary initiatives in common areas and/or for tenants or visiting help.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, ECBC- R 2018		
Performance Benchmarks				
		Assessment	Criteria	Score
Minimum Practice		No innovative strategy adopted	0	0
Good Practice		To achieve innovation point, a project must fulfil at least one criteria, or shall show exemplary performance in any of the previous mentioned categories	1	1
Final Score				0
Final Score				**0**

Results and Summary

Score Board

Category → Sub-Category ↓	Site Planning and Sustainability	Water and Waste Management	Social Co-relations	Cultural and Perceptual	Energy and Resource Management	Health and Wellbeing	Innovation
1	0	3	0	0	3	3	0
2	5	0	3	3	0	5	
3	3	0	3	3	0	3	
4	0	5	3	3	-1	3	
5	0	3	-1	3	-1	0	
6	-1				0		
7					3		

Over-All Score Board : GOOD PRACTICE

Final score	**7**	**11**	**8**	**12**	**4**	**14**	**0**
Total Expected Score for **Good Practice**	**18**	**15**	**15**	**15**	**21**	**15**	**1**
Percentage	**39%**	**73%**	**53%**	**80%**	**19%**	**93%**	**0%**

Final score	**56**
Total Expected Score for **Good Practice**	**100**
Percentage	**56%**

Percentage	**56%**
Scale Range	**40% - 60 %**
Performance	**Fair**

Scale Range	***0% - 20 %***	***20% - 40%***	***40% - 60%***	***60% - 80%***	***80% - 100%***	*The scoring and scale range is formed for good practice*
Performance	***Very Poor***	***Poor***	***Fair***	***Good***	***Excellent***	

Over-All Score Board : BEST PRACTICE

Final score	**7**	**11**	**8**	**12**	**4**	**14**	**0**
Total Expected Score for **Best Practice**	**30**	**25**	**25**	**25**	**35**	**25**	**1**
Percentage	**23%**	**44%**	**32%**	**48%**	**11%**	**56%**	**0%**

Final score	**56**
Total Expected Score for **Best Practice**	**166**
Percentage	**34%**

Percentage	**34%**
Scale Range	**20% - 40 %**
Performance	**Poor**

Scale Range	***0% - 20 %***	***20% - 40%***	***40% - 60%***	***60% - 80%***	***80% - 100%***	*The scoring and scale range is formed for best practice*
Performance	***Very Poor***	***Poor***	***Fair***	***Good***	***Excellent***	

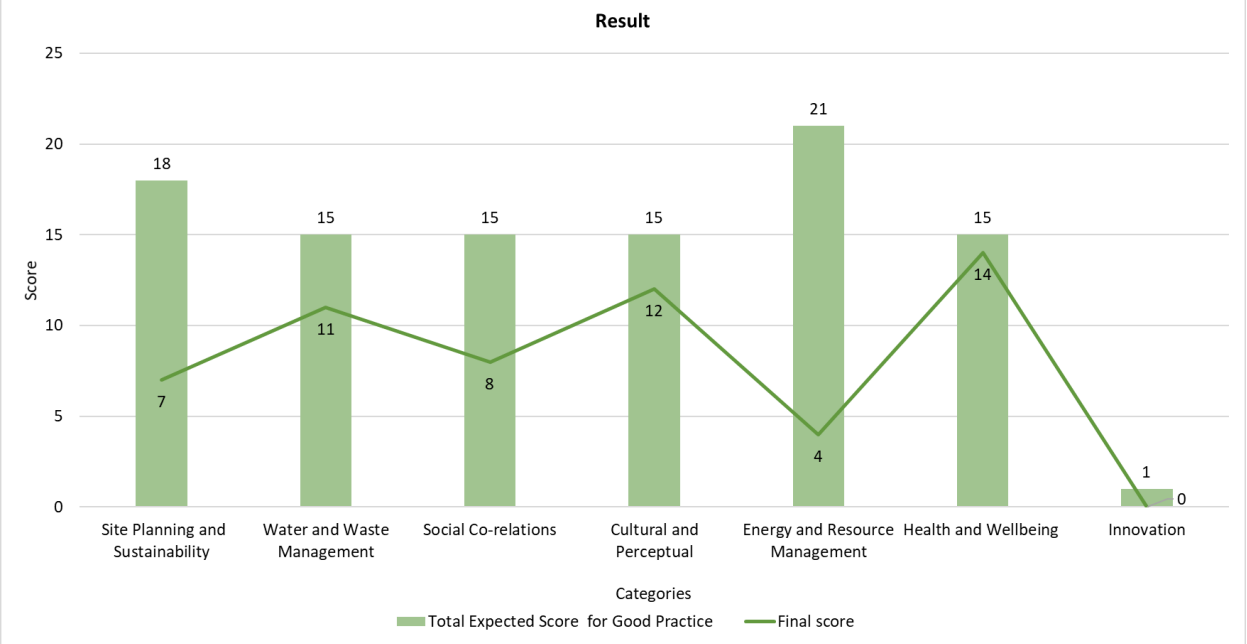
Over-All Score Board : GOOD PRACTICE							
Final score	**7**	**11**	**8**	**12**	**4**	**14**	**0**
Total Expected Score for **Good Practice**	**18**	**15**	**15**	**15**	**21**	**15**	**1**
Percentage	**39%**	**73%**	**53%**	**80%**	**19%**	**93%**	**0%**

Final score	**56**
Total Expected Score for **Good Practice**	**100**
Percentage	**56%**

Percentage	**56%**
Scale Range	**40% - 60 %**
Performance	**Fair**

Scale Range	***0% - 20 %***	***20% - 40%***	***40% - 60%***	***60% - 80%***	***80% - 100%***	*The scoring and scale range is formed for good practice*
Performance	***Very Poor***	***Poor***	***Fair***	***Good***	***Excellent***	

Analysis : Category wise



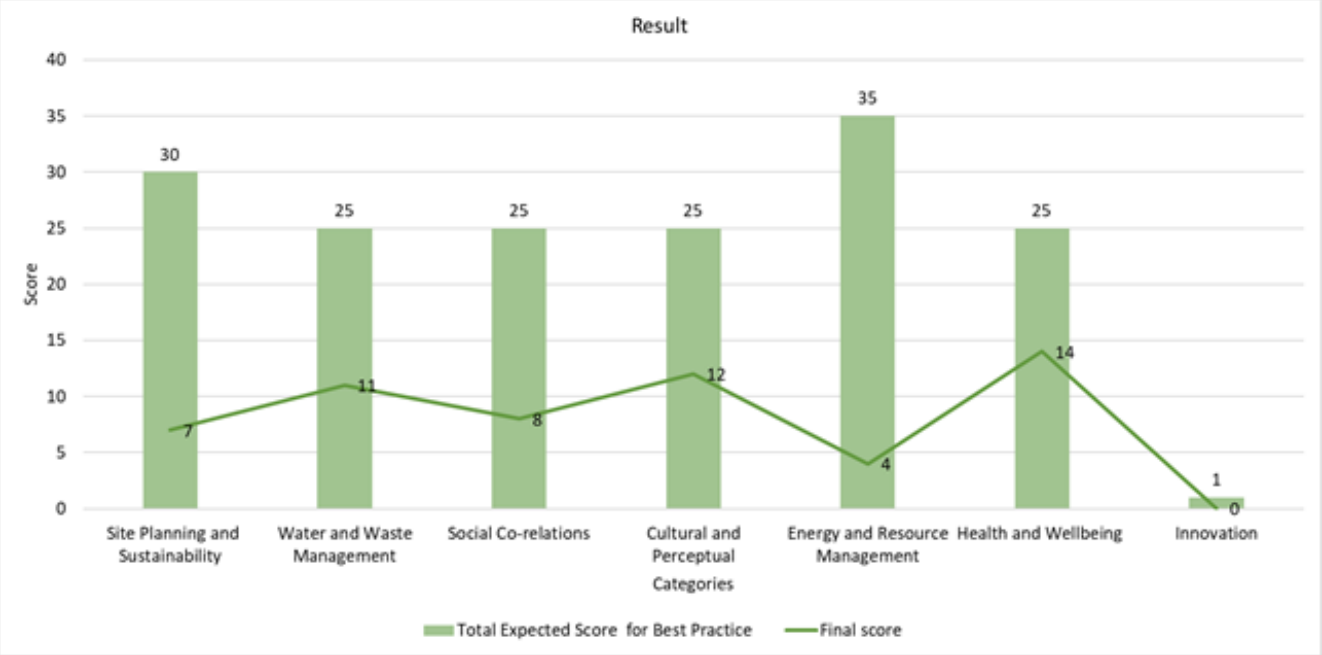
Over-All Score Board : BEST PRACTICE							
Final score	**7**	**11**	**8**	**12**	**4**	**14**	**0**
Total Expected Score for **Best Practice**	**30**	**25**	**25**	**25**	**35**	**25**	**1**
Percentage	**23%**	**44%**	**32%**	**48%**	**11%**	**56%**	**0%**

Final score	**56**
Total Expected Score for **Best Practice**	**166**
Percentage	**34%**

Percentage	**34%**
Scale Range	**20% - 40 %**
Performance	**Poor**

Scale Range	***0% - 20 %***	***20% - 40%***	***40% - 60%***	***60% - 80%***	***80% - 100%***	*The scoring and scale range is formed for best practice*
Performance	***Very Poor***	***Poor***	***Fair***	***Good***	***Excellent***	

Analysis : Category wise



ANNEXURE

DASH: VERSION II

7.5 Annexure E: DASH V2

DASH : Design Assessment Tool for Sustainable Housing
Research Project:Design and Development of DASH: Assessment Tool For Sustainable Housing

Developed by: Kratika Piparsania
Research Scholar , Department of Design, IIT Guwahati

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Introduction

This tool intents to help assess the sustainability performance, w.r.t. environmental, social and economic aspects of housing. The user guide and toolkit present key issues identified through survey and interviews with residents, that tries to bridge the gap and bring out a holistic framework for sustainable design assessment.
The proposed solution and design guidelines are the outcomes of intense research, survey and analysis.This tool might not include all the possible solutions but has attempted to fill the critical gap in the green building rating systems and comes second to it.
The toolkit covers seven categories of effect, which were identified as they have the most significant potential to reduce a building's environmental effect and to remove the most frequently met problems and barriers in a balanced sustainable design:

Site Planning and Sustainability	Water and Waste Management	Social Co-relations	Cultural and Perceptual	Energy and Resource Management	Health and Wellbeing	Innovation

Each category is divided into multiple subsections for a more thorough analysis. For each subsection, numerous sections covers the intent and assessment criteria is measured to fulfill the requirement this category. Other sections include the analysis method,compliance, reference sources, and other required criteria for evaluation and result.

Start using the Assessment Tool by clicking on the User's Guide tab.

After completing the evaluation, Toolkit users will have a tabulated set of design criteria that will serve to encourage sustainable development and green construction, as well as prevent the building community from growing in accordance with the sustainable design goals. Following the completion of the evaluation, the Toolkit assists architects in charting a transparent and open path for addressing potential design revisions with clients and the local community. The Toolkit can assist the user in developing a strategy for adopting the essential criteria and allowing for adjustments that will allow for more sustainable design and construction. In doing so, local governments can find ways to encourage developers, contractors, and design professionals to plan for and use sustainable design tools and techniques.
The Resource Guide refers to studies, research, publications, model codes/ordinances, and organizations that provide additional tools and strategies to architects and designers seeking more knowledge on sustainable design and green construction. The Resource Guide includes resources for each Toolkit category tab as well as a section on green building and design

DASH : Design Assessment Tool for Sustainable Housing

Research Project:Design and Development of DASH: Design Assessment Tool For Sustainable Housing

Developed by: Kratika Piparsania
Research Scholar , Department of Design, IIT Guwahati

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User Guide

For each subcategory, i.e. "Natural topography and vegetation under "Site planning and neighborhood" tab:

1. Read the intent and objectives.
2. Read and comprehend the pointer used to measure this sub-category's success or failure.
3. Understand the assessment criteria and performance benchmarks to be followed.
4. You may evaluate the design using the assessment criteria by choosing the option from the drop-down at the “assigned score“ that fits best to you. Score will display at the end of every subcategory and the total score.
5. The final sheet, " results" will present your score for all categories together.
6.For reference, we have already run a demo and the scores in all categories and sub-categories are assigned. You can see the final analysis in the result section.
7. The scoring for the entire sheet and every sub-section are on a scale ranging from "negative" to "Best Practice" with values (-1, 0,3, 5). All criteria within each category have been assigned equal weightage (i.e., 3 for good practice) except for innovation which is 1.
8. Each score is displayed in a color rating in the final column as green, light green, yellow, or red where in green shows the best possible practice and must continue with it; light green- shows good practice, yellow shows minimum requirements fulfilled and red shows significant need of improvement.
9. Repeat the process until all sections are answered.
10. Review the steps for each category from 1 to 7.
11. If you wish to use the tool and test it for personal project, you can ask for an editable file.

The totals for each colour are calculated and is reported after each subcategory's data, as well as the totals for the overall category at the bottom of the worksheet.
The last tab, "Result," provides a concise summary of all of the data, split down by category, as well as a chart.
This tool may be expanded or changed to meet your design requirements. As a result, if you need to add parts or areas that are not currently covered by the assessment tool, you may do so in the future based on your input, and you can copy and paste the drop down options and formulae to build the automated graphical representations and summary tables.

Division and Checklist				
Index	**Category**	**Criterion name**		**Completion Check**
1	**Site Planning and Sustainability**	1.1	Local Building Regulations	3
		1.2	Natural Topography & Vegetation	3
		1.3	Access to Amenities	3
		1.4	Low Impact Design Strategies	-1
		1.5	Soil Erosion Control	3
		1.6	Green Education & Awareness	3
2	**Water and Waste Management**	2.1	Rainwater Harvesting	3
		2.2	Water Metering	3
		2.3	Waste Water Management	3
		2.4	Separation of House-hold Waste	5
		2.5	Handling of Construction & Demolition Waste	-1
3	**Social Co-relations**	3.1	Safety and Security	-1
		3.2	Accessibility: Transportation and parking	3
		3.3	Regional Priority	0
		3.4	Interactive Dwellings	3
		3.5	Universal Accessibility	3
4	**Cultural and Perceptual**	4.1	Visual Privacy	3
		4.2	Connection with Local Values	3
		4.3	Density and Crowdedness	0
		4.4	Local Material and Technology	3
		4.5	Spatial Efficiency	3
5	**Energy and Resource Management**	5.1	Energy Optimization	0
		5.2	Alternate Water Heating system	-1
		5.3	Use of Alternative Material	3
		5.4	Building Life-Cycle Impact Reduction	0
		5.5	Renewable Energy	0
		5.6	Operation and maintenance	3
		5.7	Construction management practices	-1
6	**Health and Wellbeing**	6.1	Minimum Indoor Air Quality Performance	0
		6.2	Daylighting	3
		6.3	Noise and Acoustic Comfort	-1
		6.4	Thermal Comfort	3
		6.5	Promoting Physical Well-being	0
7	**Innovation**	7.1	Innovation	1

1 - Site Planning and Sustainability

1.1 Local Building Regulations

Intent		To ensure that the building(s) complies with necessary statutory regulatory codes.
Compliance		Design and execute the project as per the local building bye-laws.
Indicator		Following building bye-laws and other regulatory codes
Assessment Criteria		Site plan and as-built drawings approved by local Government authority
		Approved building plan/ site plan from regulatory body or Attested copies of all drawings from Principal Architect
		Declaration from developer to build as per local regulations.
		Photographs at site level and building level
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016

Performance Benchmarks

		Assessment	Criteria points	Score
Negative		Design and execute the project as per the local building bye-laws. (Fulfilling assessment criteria 1)	1	-1
Minimum practice		Design and execute the project as per the local building bye-laws. (Fulfilling assessment criteria 1 and 2)	2	0
Good Practice		Design and execute the project as per the local building bye-laws. (Fulfilling assessment criteria 1,2 and 3)	3	3
Best Practice		Design and execute the project as per the local building bye-laws. (Fulfilling all assesment criteria)	4	5
Assigned Score				**3**

1.2 Natural Topography & Vegetation				
Intent		To minimize impact to the natural topography of the site and to promote local habitat and bio-diversity there by to reduce the related long-term environmental impacts		
Compliance		Vegetation on ground and built-in structures through landscaping and land use plan		
Indicator		Following land use and landscaping guidelines as per regulatory code		
Assessment Criteria		Vegetation on Ground surface		
		Vegetation on Ground & Built structures		
		The project has to meet local-bye laws if there is a requirement of maintaining minimum vegetation / landscaping on the ground.		
		Area break up calculations (approximate) indicating the total site area, area with natural topography / vegetation on ground + built-structures.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Retain Natural topography* or Vegetation or Develop Vegetated green spaces only on ground for atleast 15% of the site area.	15%	-1
Minimum practice		Retain Natural topography* or Vegetation or Develop Vegetated green spaces only on ground for atleast 20% of the site area.	20%	0
Good Practice		Projects have option to include vegetation / greenery on ground and built-structures such as podium, roof surfaces, vertical greenery to meet atleast 30% of the site area as compliance.	30%	3
Best Practice		Projects have option to include vegetation / greenery on ground and built-structures such as podium, roof surfaces, vertical greenery to meet atleast 40% of the site area as compliance.	40%	5
Assigned Score				**3**

1.3 Access to Amenities

Intent	To reduce the negative environmental impact due to emissions from automobiles by providing basic house-hold amenities, thereby, enhancing the quality of life.
Compliance	Site must access to atleast six basic house-hold amenities, within a walking distance of 1 km from the building entrance.
Indicator	Must adhere guidelines and local regulations as per NBC 2016 and MBBL.
Assessment Criteria	Basic amenities include : Grocery store / Super market, Bank/ ATM, Medical clinic/ Hospital, Bus stop / Railway station/ Metro station/ Auto stand, Park / Garden or Playground / Jogging track/ walking , Place of Worship Educational institutions (Pre-school, School, etc.,), Refueling station , Restaurants, Salon, Clubhouse, Stores such as clothes, electrical, stationary, milk booth, pharmacy, etc., Laundry services, Sports club / Fitness center / Gym
	Within the building : one common toilet for service staff & visitors. (for less than 200 dwelling units) or as per regulation. For designing differently abled toilets the project must adhere to the local regulations or NBC 2016.
	Seating area in common spaces
	Play area for children to include tot-lot play equipment which is permanently installed
Reference/ Guide	National Building Code 2016, Model Building Bye-Laws 2016

Performance Benchmarks

	Assessment	Fulfilling Points	Score
Negative	Site must access to atleast to the following basic house-hold amenities, within a walking distance of 1 km from the building entrance and must include assessment 2,3,4 if it's a multiple dwelling unit	< 6	-1
Minimum practice		6	0
Good Practice		> 6	3
Best Practice		> 6 + Others	5
Assigned Score			**3**

1.4 Low Impact Design Strategies				
Intent		To promote design strategies that enable the project to factor in ways by which natural site features (topographical/microclimatic) can be protected and/or incorporated into the project design.		
Compliance		To show reduction in environmental impact by adoption of various low-impact planning and design strategies		
Indicator		Low-impact planning , passive architecture and design strategies		
Assessment Criteria		To reduce environmental impact by adoption of various low-impact planning Application of any active or passive design strategy . (See the appendix table 1 and 2 for strategies)		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Allocation for low impact design strategies with passive strategy	0	-1
Minimum practice			2	0
Good Practice			3	3
Best Practice			5	5
Assigned Score				**-1**

1.5 Soil Erosion Control				
Intent		Control soil erosion and sedimentation thereby, reducing negative impacts to the site and surroundings.		
Compliance		Adopting appropriate measures		
Indicator		Develop appropriate measures to address soil erosion, pre construction and post occupancy.		
Assessment Criteria		Soil erosion control measures for pre-construction and during construction must conform to the best management practices highlighted in the National Building Code 2016 (NBC*) of India. Kindly refer to Landscape practices in National Building Code 2016 (NBC*) of India, Chapter 11 – Approach to Sustainability, No. 7 – External Development & Landscape and Chapter 10, Part 10, Section 1 – Landscape Site Planning. No. 4- Protection of Landscape during Construction and No. 5. General landscape development.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Fertile topsoil to be stockpiled prior to construction, for reuse later either on site or sold/donated for use off-site.	0	-1
Minimum practice			1	0
Good Practice			2	3
Best Practice		Develop a storm-water management plan during construction to ensure that the storm-water run-offs during construction are filtered to remove the TSS* prior to conveying into the municipal storm-water drain	3	5
Assigned Score				**3**

1.6 Green Education & Awareness				
Intent		Educate the workforce during construction phase and occupants post construction to sustain the green features through the life of the building, thereby reducing the negative impacts associated on environment		
Compliance		Awareness of green home guidelines to occupants		
Indicator		Declaration from owner stating the schedule of awareness sessions planned and executed		
Assessment Criteria		a.Awareness sessions for construction workforce on green & safety measures b. Display signages indicating envisaged green features		
		a. Project brochure highlighting the green features proposed b. Awareness sessions to prospective occupants c. Circulate green home guidelines d. Permanent signages highlighting the implemented green features		
Reference/ Guide		Model Buildling Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Fulfilling Points	Score
Negative		Declaration from owner stating the schedule of awareness sessions planned + Photographs of the signages displayed in construction site, as applicable and acknowledgment of green home guidelines by occupants	0	-1
Minimum practice			1	0
Good Practice			2	3
Best Practice			3	5
Assigned Score				**3**
Final Score				**14**

2 - Water and Waste Management

2.1 Rainwater Harvesting

Intent	Enhance ground water table and reduce municipal water demand through effective rain water management.
Indicator	Design rainwater harvesting system and High Ground Water Table
Assessment Method	To calculate total rainwater harvesting potential
Relevant Information/ Assessment Criteria	Consider Rainwater Harvesting Guidelines (as and when available) from the National Building Code (NBC) of India, Part 11 - Approach to Sustainability, Section 7.2 - Rainwater Harvesting Surface Run-off.
Reference/ Guide	National Building Code 2016, Model Building Bye-Laws 2016

Performance Benchmarks

	Indicator	One-day Rainfall (% of Average Peak Month Rainfall)	Score
Negative	The total rainwater harvesting system to capture at least 'one-day rainfall*' run-off volume from roof and non-roof areas AND Rainwater is recharged into the ground water aquifer with 8m depth and has a filtration system installed	Avg peak rainfall per month up to 250 mm : 12% ; 251-300 : 10% ; 351 - 500 : 8% ; 501-700 : 6 % ; 701-above : 4 %	-1
Minimum practice		Avg peak rainfall per month up to 250 mm : 10 % ; 251-300 : 12.5 % ; 351 - 500 : 10% ; 501-700 : 7.5 % ; 701-above : 5 %	0
Good Practice		Avg peak rainfall per month up to 250 mm : 18% ; 251-300 : 15 % ; 351 - 500 : 12v% ; 501-700 : 9 % ; 701-above : 6 %	3
Best Practice		Avg peak rainfall per month up to 250 mm : 21 % ; 251-300 : 17.5 % ; 351 - 500 : 14 % ; 501-700 : 10.5 % ; 701-above : 7 %	5
Assigned Score			**3**

2.2 Water Metering				
Intent		To support water management and identify opportunities for additional water savings by tracking water consumption.		
Compliance		Quantify water used in each of the dwelling units and common area applications.		
Indicator		Install permanent water meters that measure the total potable water use for the building and associated grounds.		
Assessment Criteria		Install Water meters at dwelling unit level (Kitchen, Toilets) : 75 % - 100 % of the Dwelling unit consumption		
		Other Area Water meters (any 3 measures) for the following applications: STP treated water , Landscape water consumption, Water consumption in club house , Captured rain water reuse		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Install Water meters at dwelling unit level (Kitchen, Toilets) : 75 % - 100 % of the Dwelling unit consumption AND/OR Other Area Water meters (any 3 measures) for the following applications: STP treated water , Landscape water consumption, Water consumption in club house , Captured rain water reuse	less then 75%	-1
Minimum practice			75%	0
Good Practice			75 % - 100 % and 1 criteria	3
Best Practice			75 % - 100 % and 2 or more criteria	5
Assigned Score				**3**

2.3 Waste Water Management

Intent	Reduce consumption of potable water and waste water generation to minimize the burden on municipal water supply
Compliance	Waste Water Treatment and its reuse
Indicator	On-site treatment system , reusing options
Assessment Criteria	Provide an on-site treatment system to treat atleast 50% of waste water generated in the building/ campus, to the quality standards suitable for reuse as prescribed by Central (or) State Pollution Control Board
	Provide separate plumbing lines for reuse of treated waste water available from InSite waste water treatment plant for flushing requirements.
	Reuse treated waste water for flushing, landscaping, car washing or any other purposes, as applicable. The treated grey water for reuse must conform to the water quality standards as per the CPCB norms or local Government Authority.
Reference/ Guide	National Building Code 2016, Model Building Bye-Laws 2016 , CPCB Norms

Performance Benchmarks

	Assessment	Criteria	Score
Negative	On-site treatment system to treat atleast 50% of waste water generated in the building,; Percentage of waste water treated : X Percentage of waste water used : Y	< 50 % and < 50 %	-1
Minimum practice		Equal to 50 % and 50 %	0
Good Practice		> 50 % and > 50 %	3
Best Practice		> 95 % and > 75 %	5
Assigned Score			**3**

2.4 Separation of House-hold Waste				
Intent		Facilitate segregation of house-hold waste at source so as to prevent such waste being sent to land-fills.		
Compliance		plan showing the location of proposed waste bins at individual level.		
Indicator		Provide separate bins in every dwelling unit		
Assessment Criteria		Provide separate bins in every dwelling unit to collect dry waste (paper, plastics, metals, glass, etc.,) and wet waste (organic) at each dwelling unit and common areas (as applicable) in the building(s)/ campus. Also, provide a common facility at community level with separate bins to collect waste which covers Dry Waste, Wet waste, Batteries, 'e' waste , Lamps		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		Providing waste bins at individual level.	0	-1
Minimum practice			1	0
Good Practice			2	3
Best Practice			3	5
Assigned Score				**5**

2.5 Handling of Construction & Demolition Waste				
Intent		Encourage practices to manage construction waste, thereby, avoiding waste being sent to land-fills.		
Compliance		strategies to be implemented to handle construction waste		
Indicator		Preventing waste going to landfills		
Assessment Criteria		Avoid atleast 50% of the waste generated (by either weight or volume) during construction from being sent to landfills.		
		Excavated earth & stones should not be considered under this credit, as these are natural resources.		
		Temporary materials such as materials used for form-work, scaffolding etc., shall not be considered for credit calculations.		
		Declaration letter from scrap vendors / haulers cannot be considered. Project need to submit gate pass / challans. / receipts related to waste disposed.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Percentage	Score
Negative		Percentage of Construction Waste Materials Handled	50%	-1
Minimum practice			65%	0
Good Practice			80%	3
Best Practice			95%	5
Assigned Score				**-1**

Final Score				**13**

3 - Social Co-relations

3.1 Safety and Security

Intent		To access and stimulate plan for fire fighting in the building
Compliance		Design and contract documentation, local fire department.
Indicator		Risk level for occupants in the most vulnerable part of the building.
Assessment Criteria		Provision for fire fighters to access key parts of the building from exterior and interior points; adequacy of means of egress; fire rating of key systems.
		The minimum clear width 1.5m , minimum tread width 250 mm and maximum riser of staircases 190 mm for buildings shall be as given as below (see also Part 4 'Fire and Life Safety of NBC 2005).
		All aspects of exit requirements for corridors, doors, stair cases, ramps, etc. in respect of widths, travel distance shall be as per Part 4 'Fire and Life Safety' of NBC,2005.
		Building elements/components such as walls, columns, beams and floors shall have the requisite fire resistance rating in accordance with the accepted standards at Tables 2 to 18 of Part IV of the NBC.
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016

Performance Benchmarks

	Assessment	Criteria points	Score
Negative	To fulfil criteria from each category mentioned in the assessment list	0	-1
Minimum practice		1	0
Good Practice		2	3
Best Practice		3	5
Assigned Score			**-1**

3.2 Accessibility: Transportation and parking				
Intent		To encourage development in locations shown to have multimodal transportation choices or otherwise reduced motor vehicle use, thereby reducing greenhouse gas emissions, air pollution, and other environmental and public health harms associated with motor vehicle use. and To minimize the environmental harms associated with parking facilities, including automobile dependence, land consumption, and rainwater runoff.		
Compliance		Provide adequate transportation choices and ventilation in basements, encourage use of hybrid vehicles and bicycles.		
Indicator		Use facilities for transportation and parking to reduce carbon footprint		
Assessment Criteria		Do not provide off-street parking, Do not exceed the minimum local code requirements for parking capacity, Provide parking capacity that is a 30% reduction below the base ratios recommended Consultants Council, Provide dedicated parking for carshare vehicles, Unbundling Parking, promoting alternatives to conventionally fueled automobiles.		
		Ventilation for Basements , common Electric charging facility and bicycle parking		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, SAE Surface Vehicle Recommended Practice J1772		
Performance Benchmarks				
		Assessment	Criteria points	Score
Negative		Provide axial fans, CO sensors and meet minimum air changes per hour (ACH*) requirements as per NBC 2016 in the basement parking spaces	0	-1
Minimum practice		Provide common charging facility to cater to minimum 20-30% of the four wheelers & two wheelers in the building.	1	0
Good Practice		Functional entry within 400-800m walking distance of existing or planned bus, streetcar, or informal transit stops,	2	3
Best Practice		No Off-Street Parking and Reduce Parking, Carshare and Unbundling Parking	3	5
Assigned Score				**3**

3.3 Regional Priority				
Intent		To address geographically specific environmental, social equity, and public health priorities.		
Compliance		To fulfil any 1 criteria from each category in the following list		
Indicator		To promote regional values and technology		
Assessment Criteria		Public health : Clean and healthy environments for building occupants., Promote safe and healthy site area for construction workers, Reduce use of chemical and toxic exposures throughout the supply chain, Taking care of health of surrounding communities, Mitigate climate change to benefit global populations.		
		Social Equality : Creating fairer, healthier, and more supportive environments for those who work/live in the project, Responding to the needs of the surrounding community to promote a fair distribution of benefits and burdens, Promoting fair trade, respect for human rights, and other equity practices among disadvantaged communities , Providing basic facilities like toilets, storage space and medical help		
		Environmental concerns: Optimize energy performance, Heat Island Effect-Non Roof, Outdoor Water use Reduction, Building life-cycle impact reduction		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Total Criteria	Score
Negative		To fulfil atleast 1 criteria from each category in the following list : (3 minimum)	2	-1
Minimum practice			3	0
Good Practice			4	3
Best Practice			5	5
Assigned Score				**0**

3.4 Interactive Dwellings				
Intent		Idea for residential project and building layout in a way that encourages social exchange between residents and promote security and walkability in the vicinity		
Compliance		Design and contract documents.		
Indicator		Common gathering spaces like open veranda, parks , walking paths		
Assessment Criteria		Availability of common use and gathering space in the building or between group of units in the neighborhood by arranging units to create shaded mutual semi-public zones where neighbors can meet.		
		Limit number of dwelling that share a semi-public zone or courtyard to no more than 12. Limit the number of dwellings that share one entrance to 8 units. In multi-story development. It is always favorable to design 3 4 levels		
		Arrange dwelling entrances in the street or in one level of an apartment block to be overlooking and share one regular shape landing or lobby		
		Gear views from room's windows, balconies and terraces to street and nearby playing ground or gardens to maximize social interaction and increase safety and security.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Percentage	Score
Negative		The location of the housing entrances is clear to less than 25% of the other entrances to the housing, on the street or within the same semi-public area common to buildings.	< 25%	-1
Minimum practice		The location of the entrance to any housing can be seen from 50% of the entrances of other dwellings on the street or within the same common semi-public area or / and there are more than 12 housing units that share a common use area or one entrance	25 % - 50 %	0
Good Practice		The location of the housing entrance can be seen from 50% to 74% of other housing on the street or within the same common semi-public area with about 12 participants in the same entrance to the semi-private area or the entrance to the building	50 % - 75 %	3
Best Practice		The location of the housing entrance can be seen from 75% of other housing on the street or within the same common semi-public area with no more than 8 housing units that share the same entrance to the semi-private area or building with 4 floors of a maximum of inhabited floors	≥75%	5
Assigned Score				**3**

3.5 Universal Accessibility				
Intent		The intent of this criterion is to encourage the adoption of measures that make the built environment barrier free and accessible to all, including people who are differently abled, children's and elderly persons.		
Compliance		Review of construction documents by a specialist in universal access design.		
Indicator		The scope and quality of design measures planned to facilitate access and use of building facilities by persons with mobility or perceptual disabilities.		
Relevant Information/ Assessment Criteria		Submisison of details, floor plan and site plan in .dwg format demonstrating that the project incorporates design measures		
		Submit a narrative along with date-stamped photographs highlighting the measures implemented in the project.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, Harmonized Guidelines and Space Standards for Barrier Free Built Environment for Persons with Disability and Elderly Persons, 2016.		
Performance Benchmarks				
		Assessment	Criteria	Score
Negative		All key facilities, including outdoor facilities, entry points and hallways, are accessible to wheelchair users and visually impaired persons.	0	-1
Minimum practice		All key facilities, including outdoor facilities, entry points and hallways, are accessible to wheelchair users and visually impaired persons. In residential occupancies, design documentation indicates the percentage of dwelling units with accessible entry points, bathrooms and kitchens, with easy access from ground floor entry points, will be at least 5%.	1	0
Good Practice		All key facilities, including outdoor facilities, entry points and hallways, are accessible to wheelchair users and visually impaired persons. In residential occupancies, design documentation indicates that the percentage of dwelling units with accessible entry points same as above will be at least 20%.	2	3
Best Practice		All key facilities, including outdoor facilities, entry points and hallways, are accessible to wheelchair users and visually impaired persons. In residential occupancies, design documentation indicates the percentage of dwelling units with accessible entry points, same as above will be at least 30%.	3	5
Assigned Score				**3**
Final Score				**8**

4 - Cultural and Perceptual

4.1 Visual Privacy

Intent		To assess the level of privacy in bedroom and living areas of dwelling units in the building.
Compliance		Review of analysis prepared by the design team and Design documentation, location and type of adjacent buildings.
Indicator		The percentage of the number of housing units in which the bedrooms and living rooms are exposed and located within sight. Or windows of adjacent buildings located at a distance less than the recommended separation distance
Assessment Criteria		A minimum of 9m separation should be provided between the living area windows of facing dwelling units.
		Where the distance between windows or balconies/verandas of dwelling units is less than 12m, direct views between living area rooms of dwelling units into the principle area of private open space of other adjoining units should be screened or obscured.
		Views may be obscured through the use of solid fences, semi-permeable screening (e.g. lattice), or planting, and by offsetting the placement of windows on facing buildings so as not to create direct views between them.
		Site layouts should ensure shared driveways have a line of separation of at least 3m from bedroom windows.
		Separation could be achieved either by distance or changes in levels. Provide semi-open and semi-private areas of the dwelling with enough visual privacy. This includes terraces, balconies not adjacent to other opening/ balconies from nearby buildings. And for back gardens have high enough boundary or tree line to protect them.
		Relocate semi-open and semi-private areas of the dwelling to face street or avoid locating them next to semi-private areas and direct contact from windows of the next building.
		Applying maximum grading allowance where the position of the building garden level above ground do not exceed the original level of site before development to decrease exposure to neighbors' semiprivate zones and gardens.
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016

Performance Benchmarks

		Assessment	Criteria points	Score
Negative		The percentage of dwelling units whose bedroom and living areas are open to horizontal or downward views by others, from a point within 20 m of the exterior windows :	≥ 75 %	-1
Minimum practice			50 - 74 %	0
Good Practice			24 - 49 %	3
Best Practice			≤ 25 %	5
Assigned Score				**3**

4.2 Connection with Local Values			
Intent		To ensure that the urban design and architecture of buildings is compatible with local cultural values.	
Compliance		Subjective assessment by an experienced third-party design professional and/or sociologist.	
Indicator		Expert assessment of the degree to which new features, systems and materials are consistent with local cultural values related to urban design and architecture, including both functional and aesthetic aspects.	
Assessment Criteria		Discussion with client and design team by outside designer who has knowledge of the urban region.	
		Relevant issues include building uses, degree of access by public to site and to interior, degree of design openness.	
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016	
Performance Benchmarks			
		Assessment	Score
Negative		Architectural features of the Design are incompatible with existing cultural values related to urban design and architecture, including both functional and aesthetic aspects.	-1
Minimum practice		Architectural features of the Design are marginally compatible with existing cultural values related to urban design and architecture, including both functional and aesthetic aspects.	0
Good Practice		Architectural features of the Design are fully compatible with existing cultural values related to urban design and architecture, including both functional and aesthetic aspects.	3
Best Practice		Architectural features of the Design are an outstanding examples of compatibility with existing cultural values related to urban design and architecture, including both functional and aesthetic aspects.	5
Assigned Score			**3**

4.3 Density and Crowdedness				
Intent		To encourage the efficient use of urban land, within the context of an urban development plan. Without increasing the feeling of over crowdedness.		
Compliance		Review of site and development plans		
Indicator		Reducing feeling of crowdedness expressed by the optimal use of spaces between buildings and increasing setbacks proportionally with buildings heights		
Assessment Criteria		Consider the possible development of adjacent sites and ensure that the proposed development is guards against any potential adverse effects. Checking the neighbor's rights and building envelopes of adjacent sites will allow principal living spaces and primary views to be located where they will not be blocked. Although access point location may look obvious and convenient consider changing or moving the entrance to create more accessible entrance by less-abled demographics or increase social interaction or provide more privacy for adjacent neighbors. ventilation and privacy for all adjacent dwelling, where flexible setbacks to match or be consistence with nearby buildings Building height variance in the building to allow desirable sun to reach your neighbors.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria points	Score
Negative		Position the level of spaces between the building and street on the access level of the street to promote the social use of that space.	0	-1
Minimum practice		Create clear hierarchy and distinct of private zones inside the house, to overlooking semi-private and semi-open zones like the garden and balconies and semi-public areas that is shared between group of buildings or dwellings to completely public zones of pedestrian paths and streets	1	0
Good Practice		In multi-story development. It is always favorable to design 3 or 4 levels only that offer beside the semi-private and open zone a direct connection to street.	2	3
Best Practice		Proportional setbacks between buildings where the distance between tow buildings should be half of the average heights of them. (H1+H2/2)= min Distance between these buildings.	3	5
Assigned Score				**0**

4.4 Local Material and Technology				
Intent		To assess the extent to which traditional local materials and construction techniques will used in the execution of the project. thereby minimizing the associated environmental impacts resulting from transportation.		
Compliance		Design documents		
Indicator		Percentage of the non-structural elements of the building constructed using traditional local materials and construction techniques.		
Assessment Criteria		Estimate of percentage of traditional local materials to be used relative to total non-structural materials, by value.		
		Review by an outside design team of an analysis prepared by the design team.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, BTPMC		
Performance Benchmarks				
		Assessment	Criteria points	Score
Negative		Ensure atleast X % of the total building materials (by cost), used in the building(s)/ campus, are manufactured within a distance of 400 km	< 50 %	-1
Minimum practice			equal to 50 %	0
Good Practice			Between 50 - 75 %	3
Best Practice			> 75 %	5
Assigned Score				**3**

4.5 Spatial Efficiency				
Intent		To encourage the efficient utilization of space within buildings.		
Compliance		Design and contract documentation, including floor plans for all floors with varying net areas.		
Indicator		The ratio of directly functional net areas to total net area in each occupancy. Total Net Areas exclude only structure and building envelope areas; Net Functional Areas (NFA) exclude interior garages, vertical circulation and building mechanical rooms.		
Assessment Criteria		Net areas for all floors with varying net areas.		
		Calculation of net to gross areas for all floors of varying net area.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016		
Performance Benchmarks				
		Assessment	Criteria points	Score
Negative		The ratio of directly functional net areas to total net area within the occupancy, for the average of all floors, according to design documentation.	72	-1
Minimum practice			75	0
Good Practice			84	3
Best Practice			90	5
Assigned Score				**3**
Final Score				**12**

5 - Energy and Resource Management

5.1 Energy Optimization

Intent		Enhance energy efficiency of the building(s) to reduce environmental impacts from excessive energy use.
Compliance		Submission and review of all documents at early stages
Indicator		Ensure that the project demonstrates compliance with the mandatory requirements of ENS 2018 (ECBC -R)
Assessment Criteria		The project should design the building envelope measures as per Eco-Niwas Samhita 2018 (ECBC-R).
		The project must ensure that the interior, exterior, common and parking area lighting power densities are reduced by atleast 25% over the baseline values through 'building area method'.
		All air conditioners (single unit) must be BEE 4-star rated as per the latest notification or/BEE 5 star / Inverter based and Centralized air-conditioning system(s) must be efficient by atleast 10% over the baselines of ECBC- R / ECBC 2017. (Applicable for project only if 25% of the total regularly occupied spaces are airconditioned, excluding kitchen)
		For Space Heating Systems : Unitary heat pumps must meet the baseline criteria of ECBC-R/ ECBC 2017 and all Non-electricity based heating system should have a minimum thermal efficiency of 70%
		All non-emergency exterior & common area lighting such as façade, pathways, landscaping, surface and covered parking, street lighting, staircases should have atleast one of the following in common areas & common toilets: Day light sensor, Occupancy/ Motion sensor ,Timer based controls
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, ECBC- R 2018

Performance Benchmarks

		Assessment	Criteria points	Score
Negative		For building envelope, Residential envelope transmittance value (RETV*) for building envelope (except roof) shall be 15 W/m²K , U value of Roof assembly of 1.2 W/m²K.Reduction in Interior, Exterior Common & Parking Area LPDs from Baseline Values ≥ 25%.Efficiency in Centralized Air-conditioning Systems from Baseline Values ≥ 10% + Lighting control + space heating systems	0	-1
Minimum practice		For building envelope, Residential envelope transmittance value (RETV*) for building envelope (except roof) shall be 15 W/m²K , U value of Roof assembly of 1.2 W/m²K.Reduction in Interior, Exterior Common & Parking Area LPDs from Baseline Values ≥ 25%.Efficiency in	1	0

		Centralized Air-conditioning Systems from Baseline Values ≥ 10% + Lighting control + space heating systems		
Good Practice		For building envelope, Residential envelope transmittance value (RETV*) for building envelope (except roof) shall be 13 W/m²K , U value of Roof assembly of 1.0W/m²K.Reduction in Interior, Exterior Common & Parking Area LPDs from Baseline Values ≥ 30%. Efficiency in Centralized Air-conditioning Systems from Baseline Values ≥ 20% + Lighting control + space heating systems	2	3
Best Practice		For building envelope, Residential envelope transmittance value (RETV*) for building envelope (except roof) shall be 13 W/m²K , U value of Roof assembly of 1.0W/m²K. Reduction in Interior, Exterior Common & Parking Area LPDs from Baseline Values ≥ 30%. Efficiency in Centralized Air-conditioning Systems from Baseline Values ≥ 20% + Lighting control + space heating systems	3	5
Assigned Score				**3**

5.2 Alternate Water Heating system				
Intent		Encourage use of alternate water heating systems to improve energy efficiency.		
Compliance		Provide any one or combination of the below technologies for atleast 50 % of hot water		
Indicator		Awareness and implementation of alternate energy source		
Assessment Criteria		The minimum hot water requirement for domestic purposes should be considered as 20 liters per person per day.		
		The minimum temperature requirement of hot water to be considered for domestic applications can range between 35-40 deg C.		
		Alternate source could be : Natural Gas (or) LPG based systems, Heat pump with minimum of COP 3.2 , Solar water heating systems		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, ECBC- R 2018		
Performance Benchmarks				
		Assessment	Criteria points	Score
Negative		Hot water through alternative heating systems as a percentage of total hot water requirement of the building(s)	> 50 %	-1
Minimum practice			50%	0
Good Practice			75%	3
Best Practice			95%	5
Assigned Score				**-1**

5.3 Use of Alternative Material				
Intent		Encourage use of alternative construction materials to conserve natural resources and thereby reduce environmental impacts and minimize use of new wood-based products, thereby reducing impacts of deforestation.		
Compliance		Submission and review of all documents at early stages		
Indicator		Use of alternate materials for external and internal site work		
Assessment Criteria		Ensure new wood-based products (by cost) used in the building : Rapidly renewable or Composite / Agri based wood** / Recycled waste wood or Wood certified by Forest Stewardship Council (FSC) or Programme for the Endorsement for Forest Certification (PEFC) or equivalent		
		Source atleast 5% -10% of the building construction using alternative materials.		
		Ensure that at least 70% of all roads and vehicular pathways within site premises are constructed with one, or any combination, of substitute materials		
		Ensure atleast 50% - 75% of the total building materials (by cost), used in the building(s), are manufactured within a distance of 400 km.		
		Use atleast 5% - 25% certified green building materials, products, and equipment, so as to reduce dependence on materials that have associated negative environmental impacts.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, ECBC- R 2018		
Performance Benchmarks				
		Assessment	Criteria points	Score
Negative		Not fulfilling any criteria fully	0	-1
Minimum practice		Fulfilling any one of the criteria	1	0
Good Practice		Fulfilling more than 1 criteria	2	3
Best Practice		Fulfilling more than 2 criteria	3	5
Assigned Score				**3**

5.4 Building Life-Cycle Impact Reduction				
Intent		To encourage adaptive reuse and optimize the environmental performance of products and materials.		
Compliance		Demonstrate reduced environmental effects during initial project decision-making by reusing existing building resources or demonstrating a reduction in materials use through life-cycle assessment.		
Indicator		To Reuse and reduce the over all impact		
Assessment Criteria		For existing building : Maintain the existing building structure, envelope, and interior nonstructural elements of a old building. Must adhere by local bye laws		
		Maintain at least 50%, by surface area, of the existing building structure, enclosure, and interior structural elements for buildings that meet local criteria of abandoned or are considered blight.		
		Reusing the existing building material from on site/ off site, ranging from 25 - 75 %		
		For new construction (buildings or portions of buildings), conduct a life-cycle assessment of the project's structure		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, ECBC- R 2018		
Performance Benchmarks				
		Assessment	Criteria points	Score
Negative		Achieve any one of the above mentioned criteria.	0	-1
Minimum practice			1	0
Good Practice			2	3
Best Practice			3	5
Assigned Score				**0**

5.5 Renewable Energy				
Intent		The intent of this criterion is to promote the use of RE in the projects and, thereby, reduce the project's dependency on fuels derived from conventional sources.		
Compliance		Onsite and/ or offsite combination renewable energy system		
Indicator		Awareness and implementation of renewable energy		
Assessment Criteria		Installation of on-site and off-site RE system to offset a part of the annual energy consumption of internal artificial lighting, HVAC, and domestic hot water systems		
		100% of the annual energy consumption of internal artificial lighting, HVAC, and domestic hot water systems is offset through off-site RE systems.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, ECBC- R 2018		
Performance Benchmarks				
		Assessment	Criteria points	Score
Negative		Point weightage for on-site and off-site renewable energy system installation	10%	-1
Minimum practice			15%	0
Good Practice			20%	3
Best Practice			25%	5
Assigned Score				**0**

5.6 Operation and maintenance				
Intent		The intent of this criterion is to ensure the incorporation of detailed O&M procedures for various systems in the building.		
Compliance		Methods for designing building envelope components prepared for repair and maintenance		
Indicator		Degree of technical and design difficulty and capital cost requirements linked to expansion possibilities.		
Assessment Criteria		To ensure that a core facility/service group is formed, which will be responsible for the O&M of the building systems and equipment post installation.		
		Ceiling lights installed that can only be accessed and changed out with scaffolding.		
		Lights installed in new buildings that are not accessible at all; ultimately, these will be abandoned when the lamps fail.		
		Lights, pipes or electrical wiring requiring panels, walls or ceiling to be partially or completely cut throw or demolished		
		High-cost, custom lighting fixtures/lamps installed in parking garages. As they fail, these will be replaced with lower-cost fixtures.		
		Rooftop equipment units with no elevator access to bring replacement or maintenance/refilling chemicals or equipment.		
		Trees planted near the building's foundations		
		Lack of enough telephone, electrical, and computer outlets/cables.		
		Equipment, piping, wiring installed easily during construction that is nearly inaccessible after final walls and other appurtenances are completed.		
		High-maintenance equipment installed with no local vendor support.		
		The main pipes lines go underfloor or are cast inside the wall where it's inaccessible after building and will eventually lead to moisture and water leaking inside the envelope.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, ECBC- R 2018		
Performance Benchmarks				
		Assessment	Criteria points	Score
Negative		No criteria have been meet for future maintenance and efficient operation of the facility.	0	-1
Minimum practice		At least 3 criteria have been meet for future maintenance and efficient operation of the facility.	3	0
Good Practice		At least 5 criteria have been meet for future maintenance and efficient operation of the facility.	5	3
Best Practice		At least 7 criteria have been meet for future maintenance and efficient operation of the facility.	7	5
Assigned Score				**3**

5.7 Construction management practices				
Intent		The intent of this criterion is to ensure adoption of good management practices on-site during the construction phase.		
Compliance		To optimize resource management and ensure safe practices		
Indicator		Adoption of construction management practices and minimize waste		
Assessment Criteria		Adopt construction management practices (e.g., stacking and storage of construction materials at different stages of construction) and ensure safe disposal of waste generated during construction.		
		Adopt at least two strategies from the list, as given below, to minimize water consumption during construction, : Use gunny bags, ponding technique, or curing compound; Meter and monitor the consumption of water during construction ; Use water-reducing admixtures in concrete mix; Use treated wastewater and/or captured storm water.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, ECBC- R 2018		
Performance Benchmarks				
		Assessment	Criteria points	Score
Negative		Achieve criteria 1 and any two from the second mentioned criteria.	0	-1
Minimum practice			1	0
Good Practice			2	3
Best Practice			3	5
Assigned Score				**-1**
Final Score				**7**

6 - Health and Wellbeing

6.1 Minimum Indoor Air Quality Performance

Intent	To contribute to the comfort and well-being of building occupants by establishing minimum standards for indoor air quality (IAQ).
Compliance	To ensure fresh and good quality air
Indicator	Dwelling-unit ventilation, Exhaust, Naturally Ventilated Spaces

Assessment Criteria	Ensure that the minimum requirements of CPCB (NAAQS) for assessing the quality of fresh air are fulfilled
	Ensure that the minimum requirements of ASHRAE Standard 62.1–2010, Sections 4–7, Ventilation for Acceptable Indoor Air Quantity (with errata), or NBC 2016, Volume 2, Part 8, Section 3, for quantity of fresh air are met.
	Ensure continuous monitoring of CO, CO2, temperature, and RH levels such that they meet the permissible thresholds as per ISHRAE standard 10001:2016, for all habitable areas either at space level or at AHU's by installation of sensor(s) deployed with feedback system
	Sensors/monitoring devices
	Display sensors
	Ensure that all interior wall and ceiling finishes (including, but not limited to, primers and paints) have low VOC content and are lead free
	Ensure that all adhesives and sealants used have low VOC content and that interior composite wood products do not have urea–formaldehyde as a bonding resin
	Ensure improved indoor air quality by adopting a minimum of three strategies

Reference/ Guide	CPCB (National Ambient Air Quality Standards [NAAQS]) , National Building Code 2016

Performance Benchmarks

	Assessment	Criteria points	Score
Negative	Ensure that all interior wall and ceiling finishes (including, but not limited to, primers and paints) have low VOC content and are lead free and any 1 of the above	0	-1
Minimum practice		1	0
Good Practice		2	3
Best Practice		3	5
Assigned Score			**0**

6.2 Daylighting				
Intent		To ensure an adequate level of daylight in all essential occupancy areas.		
Compliance		Residential : Single and Multifamily units		
Indicator		Measuring the expected daylight factor in primary occupancy areas.		
Assessment Criteria		Daylight Autonomy requirement (<3000 lux) is met for 100% of the annual analysis hours for 100% of the regularly occupied areas		
		Daylight Autonomy requirement (>300 lux) is met for the annual analysis hours for 100% of the regularly occupied areas		
		WWR does not exceed 60% and the vertical fenestration complies with minimum VLT of 0.27		
		Ensure that the project meets the SHGC compliance /weighted façade average SHGC for each orientation. OR Conduct solar path analysis for windows of AC as well as non-AC spaces, to ensure that the window is completely shaded for the duration between 0900 hours on 15th March to 1500 hours on 15th September		
		Ensure that the SRR does not exceed 5% and SHGC for skylights does not exceed 0.35		
		Ensure that all regularly occupied areas meet or exceed illuminance level between 100 lux and 2000 lux for the minimum percentage of floor area for 90% of the potential day lit time in a year		
		Artificial lighting design to fall within limits (lower and higher range limits) as recommended space/task specific lighting levels as per NBC 2016 and to meet a minimum uniformity ratio of 0.4.		
Reference/ Guide		https://www.teriin.org/sites/default/files/2021-11/Inside_Integrated-daylight-system.pdf, National Building Code 2016		
Performance Benchmarks				
		Assessment	Criteria points	Score
Negative		Fulfill criteria 1, 3, 4 and any other 2	0	-1
Minimum practice			1	0
Good Practice			2	3
Best Practice			3	5
Assigned Score				**3**

6.3 Noise and Acoustic Comfort				
Intent		To promote occupant's comfort and well-being by providing effective acoustic design and reducing noise impact		
Compliance		Reduce noise impact by HVAC and other envelope acoustic performance		
Indicator		To ensure comfort by reducing noise impact		
Assessment Criteria		In each regularly occupied space, achieve maximum background noise levels from heating, cooling and ventilation systems to ensure they are at or below the following thresholds: 35 dBA for living areas and 45 dBA for kitchens and baths : HVAC background Noise		
		Floor/ceiling assemblies between dwelling units or between a dwelling unit and a public or service area stair, exterior mechanical equipment, or other mechanical equipment space, including boiler rooms, shall be constructed of assemblies with a minimum impact insulation class (IIC) rating of 50		
		Exterior windows in dwelling units, must have a minimum STC rating of 34 and Dwelling unit entrance doors (either from common hallways or the exterior) must have a minimum STC rating of 30. : Envelope Acoustic Performance		
		Walls, partitions and floor/ceiling assemblies separating dwelling units from each other, from adjacent occupancies, from public or service areas, from stairs or from mechanical equipment spaces, including boiler rooms, or elevator or other shafts shall have a minimum sound transmission class (STC) rating of 50. Penetrations or openings in construction assemblies for piping; electrical devices; recessed cabinets; bathtubs; soffits; or heating, ventilating or exhaust ducts shall be sealed, lined, insulated or otherwise treated to maintain the required rating.		
Reference/ Guide		International Electrotechnical Commission (2013) IEC 61672-1:2013 Electroacoustics, National Building Code 2016		
Performance Benchmarks				
		Assessment	Criteria points	Score
Negative		Ensure fulfilling criteria from all assessment indicators mentioned	1	-1
Minimum practice			2	0
Good Practice			3	3
Best Practice			4	5
Assigned Score				**-1**

6.4 Thermal Comfort				
Intent		To promote occupant's comfort and well-being by providing quality thermal comfort.		
Compliance		The project meets the thermal comfort requirements for all regularly occupied spaces		
Indicator		To ensure comfort by maintaining thermal performance		
Assessment Criteria		For each dwelling unit : Heating and cooling controls are installed in every unit		
		All regularly occupied spaces (air conditioned spaces) meet the thermal comfort requirements as per NBC 2016, ASHRAE 55, or the Indian Adaptive Comfort model ensuring that the maximum number of unmet hours do not exceed 300		
		All the regularly occupied spaces (Non-air-conditioned Spaces with Operable Windows)meet the thermal comfort requirements as per NBC 2016, ASHRAE 55 or the Indian Adaptive Comfort model for 90% of the occupied hours for buildings in composite, moderate, hot and dry, and cold climates, and 60% of the occupied hours for buildings in warm and humid climate		
		The optimum size/number of fans are installed in rooms of different sizes in accordance with NBC 2016.		
Reference/ Guide		National Building Code 2016, ASHRAE 55, The Indian Adaptive Comfort		
Performance Benchmarks				
		Assessment	Criteria points	Score
Negative		Demonstrate that the project meets the thermal comfort requirements for all regularly occupied spaces	0	-1
Minimum practice			1	0
Good Practice			2	3
Best Practice			3	5
Assigned Score				**3**

6.5 Promoting Physical Well-being				
Intent		Promote occupant well-being so as to enhance physical, emotional and spiritual well-being of building occupants		
Compliance		the recreational facilities provided based on the number of occupants.		
Indicator		Provision of well-being facilities		
Assessment Criteria		The project has occupant well-being facilities (such as gymnasium, aerobics, yoga, meditation, swimming pool or any indoor / outdoor games) to cater to at least 2.5% of building occupants at any point during the day		
Reference/ Guide				
Performance Benchmarks				
		Assessment	Criteria points	Score
Negative		The project has occupant well-being facilities (such as gymnasium, aerobics, yoga, meditation, swimming pool or any indoor / outdoor games) to cater to at least X % of building occupants at any point during the day	> 2.5 %	-1
Minimum practice			Equal to 2.5 %	0
Good Practice			2.5 - 5 %	3
Best Practice			> 5 %	5
Assigned Score				**0**
Final Score				**5**

7 - Innovation

7.1 Innovation				
Intent		To promote adoption and implementation of innovative strategies to enhance the sustainability quotient of the project.		
Compliance		Detailed depiction of innovation or innovative performance/ strategies implemented in the building.		
Indicator		To encourage projects to achieve exceptional or innovative performance.		
Assessment Criteria		Initiative for Gender neutral design/ Heritage conservation / safety and security		
		Any comprehensive strategy / dynamic performance		
		Strategy to enhance the overall sustainability/ any sustainable design practice/ zero waste management / using EPD (min 5)		
		Regional priority consideration		
		Voluntary initiatives in common areas and/or for tenants or visiting help.		
Reference/ Guide		National Building Code 2016, Model Building Bye-Laws 2016, ECBC- R 2018		
Performance Benchmarks				
		Assessment	Criteria points	Score
Minimum Practice		No innovative strategy adopted	0	0
Good Practice		To achieve innovation point, a project must fulfil at least one criteria, or shall show exemplary performance in any of the previous mentioned categories	1	1
Assigned Score				**1**

Final Score				**1**

Results and Summary

Over All Score Board

Category → Sub-Category ↓	Site Planning and Sustainability	Water and Waste Management	Social Co-relations	Cultural and Perceptual	Energy and Resource Management	Health and Wellbeing	Innovation
1	3	3	-1	3	3	0	1
2	3	3	3	3	-1	3	
3	3	3	0	0	3	-1	
4	-1	5	3	3	0	3	
5	3	-1	3	3	0	0	
6	3				3		
7					-1		

Over-All Score Board : GOOD PRACTICE

Final score	11	13	8	12	7	5	1
Total Expected Score for Good Practice	18	15	15	15	21	15	1
Percentage	61%	87%	53%	80%	33%	33%	100%

Final score	57
Total Expected Score for Good Practice	100
Percentage	57%

Percentage	57%
Scale Range	41% - 60%
Performance	Fair

Scale Range	*0% - 20 %*	*21% - 40%*	*41% - 60%*	*61% - 80%*	*81% - 100%*	*The scoring and scale range is formed for good practice*
Performance	*Very Poor*	*Poor*	*Fair*	*Good*	*Excellent*	

Over-All Score Board : BEST PRACTICE

Final score	11	13	8	12	7	5	1
Total Expected Score for Best Practice	30	25	25	25	35	25	1
Percentage	37%	52%	32%	48%	20%	20%	100%

Final score	57
Total Expected Score for Best Practice	166
Percentage	34%

Percentage	34%
Scale Range	21% - 40%
Performance	Poor

Scale Range	*0% - 20 %*	*21% - 40%*	*41% - 60%*	*61% - 80%*	*81% - 100%*	*The scoring and scale range is formed for best practice*
Performance	*Very Poor*	*Poor*	*Fair*	*Good*	*Excellent*	

Over-All Score Board : GOOD PRACTICE

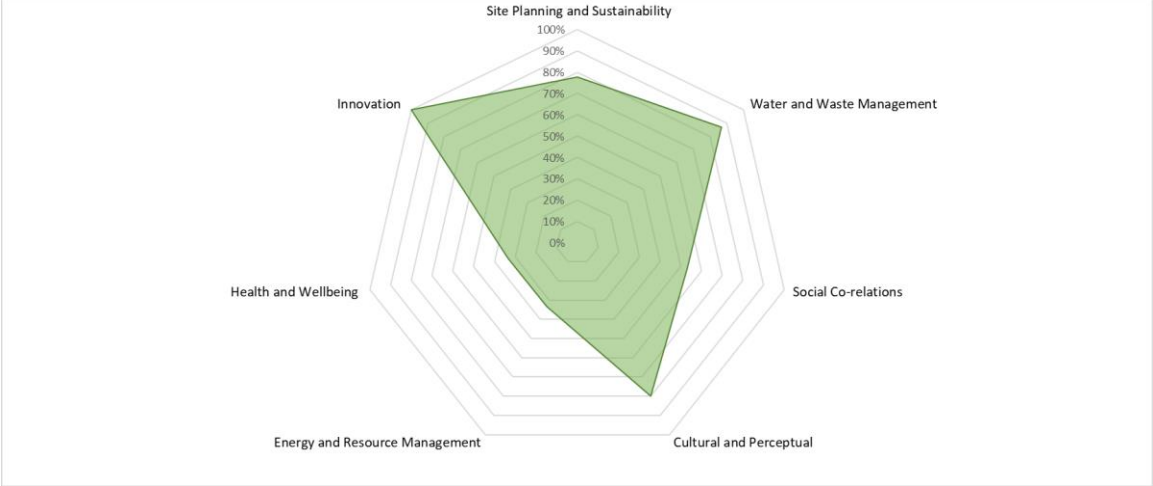
Final score	14	13	8	12	7	5	1
Total Expected Score for **Good Practice**	18	15	15	15	21	15	1
Percentage	78%	87%	53%	80%	33%	33%	100%

Final score	60
Total Expected Score for **Good Practice**	100
Percentage	60%

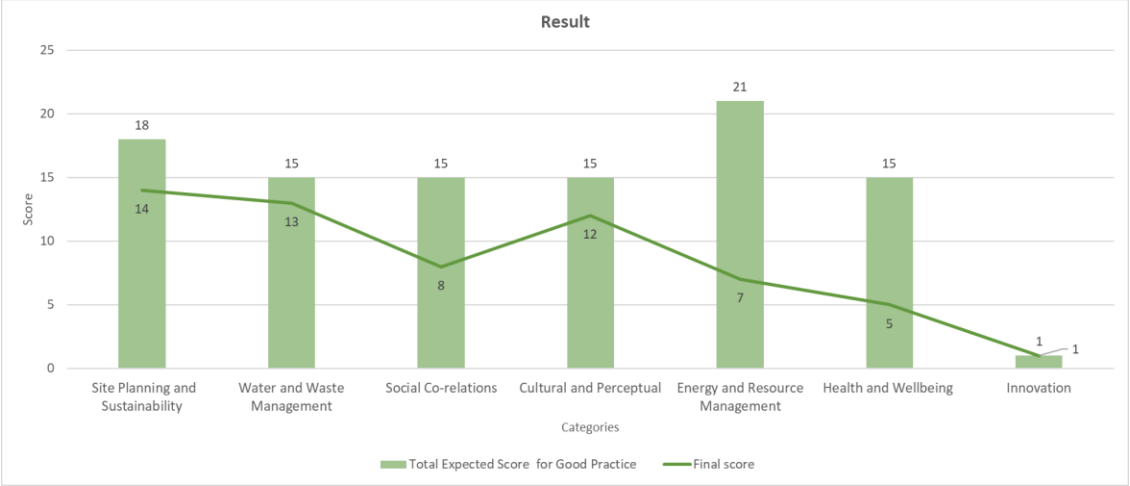
Percentage	60%
Scale Range	41% - 60%
Performance	Fair

Scale Range	*0% - 20 %*	*21% - 40%*	*41% - 60%*	*61% - 80%*	*81% - 100%*	*The scoring and scale range is formed for good practice*
Performance	*Very Poor*	*Poor*	*Fair*	*Good*	*Excellent*	

Analysis : Category wise (Percentage)



Analysis : Category wise (Scoring)



Over-All Score Board : BEST PRACTICE

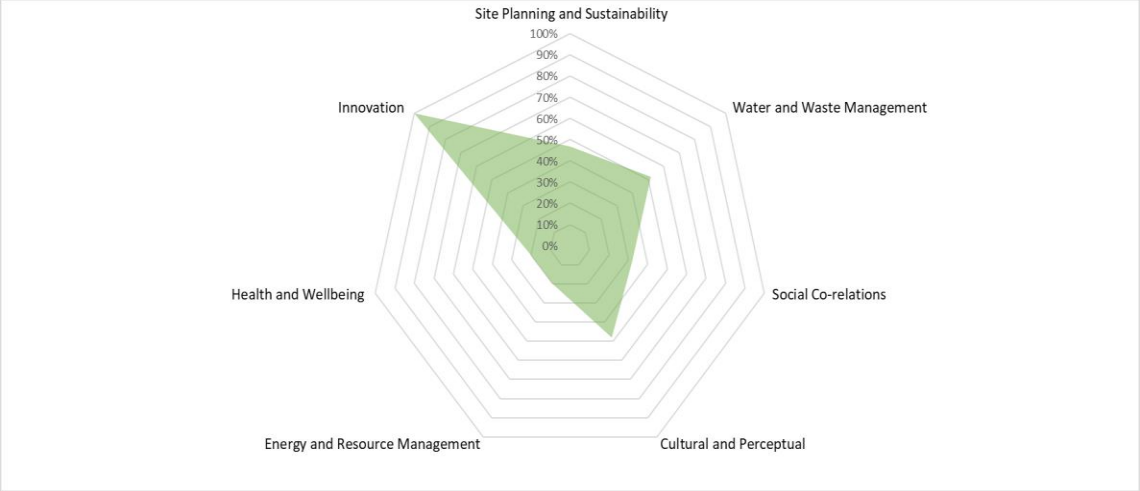
Final score	14	13	8	12	7	5	1
Total Expected Score for **Best Practice**	30	25	25	25	35	25	1
Percentage	47%	52%	32%	48%	20%	20%	100%

Final score	60
Total Expected Score for **Best Practice**	166
Percentage	36%

Percentage	36%
Scale Range	21% - 40%
Performance	Poor

Scale Range	*0% - 20 %*	*21% - 40%*	*41% - 60%*	*61% - 80%*	*81% - 100%*	*The scoring and scale range is formed for best practice*
Performance	*Very Poor*	*Poor*	*Fair*	*Good*	*Excellent*	

Analysis : Category wise (Percentage)



Analysis : Category wise (Scoring)